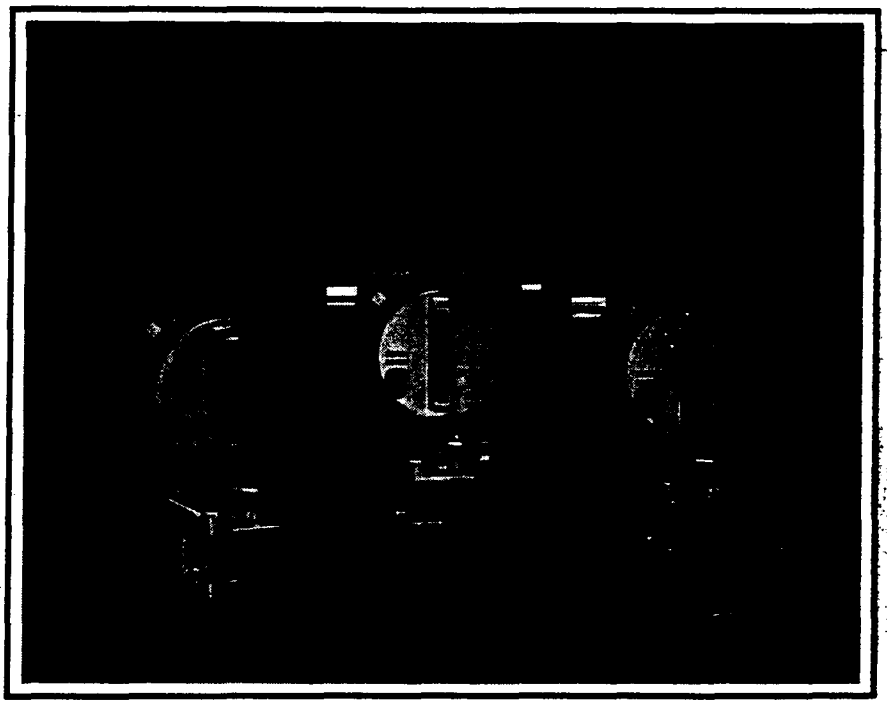
PPV VAPORIZER

SERVICE MANUAL



THE Company for Anesthesia and Critical Care Products

Penlon

Inter Med

IMPORTANT

Servicing and Repairs

In order to ensure the full operational life of the PPV vaporizer, servicing by a Penlon-trained engineer should be undertaken periodically.

We recommend that a Function Test should be performed 3 monthly (6 monthly maximum interval) comprising a LEAK TEST and a CALIBRATION check.

(Calibration check to be performed using a suitable agent analyser, e.g. Riken refractometer).

Should the calibration check show the unit to be outside the specified performance requirement (e.g. ± 20% of scale reading) then a basic service must be performed.

All vaporizers must be fully overhauled and certain items replaced every 5 years, even if the performance appears satisfactory. This is a preventative maintenance requirement.

This may be done on site by:

(a) Trained user.
(b) Authorized Penlon agent.
(c) Penlon service engineer.

For any enquiry regarding the servicing or repair of this vaporizer, contact the nearest accredited Penlon agent*, or communicate directly with Penlon's Service Department.

*Agent's name and address:

Service and Repair Department
Penlon Limited
Abingdon
Oxfordshire
OX14 3PH
England

Telephone: Abingdon (0235) 554222
Telex: 837129
Cables: Penlon, Abingdon
Fax: (0235) 555252

Always give as much of the following information as possible:

1. Type of equipment
2. Product name
3. Serial number
4. Approximate date of purchase
5. Apparent fault

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FOREWORD

This manual has been produced to provide authorized personnel with information on the function, routine performance and maintenance applicable to the Penlon PPV vaporizer.

The information contained in the manual is correct at the date of publication. The policy of Penlon Ltd. is one of continued improvement to their products. Because of this policy Penlon Ltd. reserve the right to make any changes, which may affect instructions in this manual, without giving prior notice.

Personnel must make themselves familiar with the contents of this manual before using the apparatus.

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USER RESPONSIBILITY

This anaesthetic device has been built to conform with the specification and operating procedures stated in this manual and/or accompanying labels and notices when checked, assembled, operated, maintained and serviced in accordance with the instructions provided. To ensure the safety of this device, it must be checked and serviced to at least the minimum standards laid out in this manual. A defective, or suspected defective, product must not under any circumstances be used.

Worn, broken, distorted, contaminated or missing components must be replaced immediately. Should such a repair become necessary, it is recommended that a request for service advice be made to the nearest Penlon Service Centre.

This device and any of its constituent parts must be repaired only in accordance with written instructions issued by Penlon Ltd. and must not be altered or modified in any way without the written approval of Penlon Ltd. The user of this equipment shall have the sole responsibility for any malfunction which results from improper use, maintenance, repair, damage or alteration by anyone other than Penlon Ltd. or its appointed agents.

USA and Canadian Federal Law restricts the sale and use of this device to, or on the order of, a licensed practitioner.

1. WARNINGS AND CAUTIONS

Statements in this manual preceded by the following words are of special significance:

WARNING – means there is a possibility of injury to yourself or others.

CAUTION – means there is a possibility of damage to the apparatus or other property.

NOTE – indicates points of particular interest for more efficient and convenient operation.

WARNINGS

1. **The PPV vaporizer is to be sold to, and used on, the order of a medically qualified practitioner only.**

2. **Anaesthetic agents are poisonous and inhaling their vapours, even in low (sub-anaesthetic) concentrations, may present a health hazard.**

3. **The procedures described herein, which involve dismantling vaporizers must only be performed after the instrument has been drained and dried out.**

4. **Calibration procedures must only be performed with the vaporizer outlet connected to an anaesthetic gas scavenging system designed in accordance with national standards or regulations.**

5. **No oil or grease should be permitted in the vaporizer service area. This applies equally to silicone based lubricants and flammable oil or grease. Only PTFE based oxygen compatible lubricants may be used.**

6. **The PPV vaporizer is designed for use only with one anaesthetic agent which is named on the filler and control knob. Misdosage may occur if the vaporizer is filled with the wrong drug.**
   Keyed filler devices are provided on certain models to meet national and international standards (see section 8 for standards).

7. **The pharmocopoeia name of the drug is used on the label according to BP, USP or Ph EUR. The user is responsible for confirming that any trade name of a drug is equivalent to the registered name.**

8. **If a vaporizer is transported when filled with liquid drug the control must be in the zero position during transport and a period of at least two minutes in a secured upright position must elapse before connection to a patient.**
   Movement during transport can result in over-dosage unless time is allowed for drainage of liquid to the normal position.

9. **The vaporizer control must be in the zero position during the filling or draining process. Delivered concentrations are inaccurate while the filler port is open.**
   The vaporizer must be upright during filling, to prevent overfilling.

10. **Vaporizers may malfunction if exposed to excessively high temperatures, e.g. by storage above a radiator. This may permanently damage the temperature compensation device.**
    Maximum storage temperature, 122°F (50°C)
    Minimum storage temperature – 5°F (–20°C).

11. **Vaporizer outputs are sensitive to barometer pressure and a correction factor may be necessary when assessing the output using an analyser, for example at high altitude. Barometric pressure effects are not usually of clinical importance. (See service record book).**

12. **Anaesthetic drugs must be treated as a pharmaceutical product. Liquid should never be drained from a vaporizer into an open container and then re-used. Contamination is likely. Always dispose of such drained liquid as a hazardous chemical.**

13. **The PPV vaporizer must not be modified or disassembled by any unauthorized person. It should be regularly serviced by a Penlon authorized service agent, trained technician or engineer and by no other person (see section 6).**

CAUTIONS

1. The instructions given in this manual assume that the service engineer has received adequate training in the practice of servicing anaesthetic apparatus and is familiar with the use of flowmeters, pressure gauges and other laboratory equipment. No details of such procedures are therefore included.

2. Each PPV vaporizer is a tested and calibrated unit. It is most important that components are not transferred from one unit to another. In particular, the service engineer must accept responsibility for ensuring that agent specific items such as labelling, keyed fillers, and control needles are treated as critical devices and that full records of vaporizer servicing are kept. Following a service, a label to indicate to clinical staff that the vaporizer has been serviced must be attached to each unit.

2. INTRODUCTION

These vaporizers are designed for incorporation in the fresh gas supply system of continuous flow anaesthetic machines, directly connected between the flowmeter unit and the common gas outlet of the machine.

They are unsuitable for use within a breathing system 'in circuit' because of the relatively high internal resistance.

Their purpose is the provision of accurate concentrations of anaesthetic drugs in the fresh gas supply, in accordance with the setting of the control knob, when the fresh gas supply is between 1 and 10 l/min. Predictable concentrations can be provided below 1 l/min and between 10 and 15 l/min by reference to the information in Performance Characteristics in the user manual (section 8) which shows modifications to the control knob calibration.

3. SAFETY REGULATIONS

3.1 Environment

The servicing of the PPV vaporizer must be carried out in a stable temperature environment, preferably with thermostatically controlled heating or air conditioning maintaining, within ± 1°C, a temperature between 20 and 22°C. The ability to change the temperature of a portion of the laboratory between 16 and 36°C is desirable but not essential for routine testing.

Space – approximately 1 metre square of work bench.

3.2 Equipment

Gas supply – calibration after servicing should be carried out using oxygen, but compressed air may be used if allowance is made for the small change from scale (see user's manual). Any compressed air supply must be clean, dry and oil free. We recommend medical air cylinders as the preferred alternative to oxygen.

Test rigs – layouts and components are listed in the following pages.

Small tools – as listed on the service charts S1 – S5 and section 6.2.

Each PPV vaporizer is supplied with a service record book.

All service measurements should be recorded in the service record book according to the instructions provided.

NOTE For complete safety in the service of this device, full reference must be made to the WARNINGS and CAUTIONS listed in section 1.

4. FUNCTIONAL DESCRIPTION

The user's manual for the PPV vaporizer (Doc PP18SU1) provides a detailed specification and notes on the installation and operation of the apparatus. The service engineer should have a copy of this manual for reference in addition to the following text:

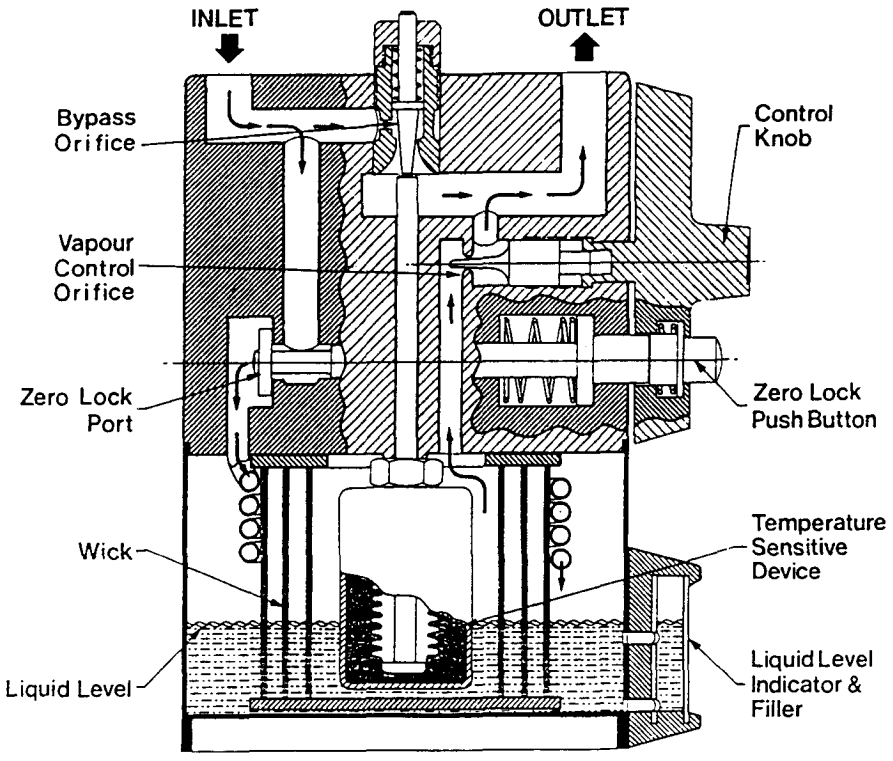


Fig. 1 Gas Flow Schematic

4.1 General Description and Diagram of Gas Flow

The PPV vaporizer is a device which enables the anaesthetist to add a pre-determined amount of the saturated vapour of a volatile drug to the fresh gas stream going to the patient's breathing system.

All anaesthetic agents of a volatile nature have relatively high vapour pressures at normal room temperature so that this saturated vapour must be diluted considerably to produce the concentrations required clinically.

Referring to Figure 1 the PPV vaporizer contains two paths for gas flow, one which is always open, through the bypass valve, and a second, which is open only when the control knob is moved from '0', via the closing mechanism, (or zero lock port), vapour chamber, and, vapour control orifice, joining up with the bypass passage in a mixing chamber adjoining the outlet.

The vapour chamber contains the liquid anaesthetic drug, and is filled through the filler unit to a level shown on the level indicator. The chamber contains a spiral assembly of wicks. Gas which enters the chamber has to pass through the narrow passages between the wicks, becoming saturated with vapour before emerging through the vapour control orifice.

The proportion of the total flow which passes through the vapour chamber is determined by the relative resistances of the bypass orifice (which does not vary in size with control knob setting, but does vary with temperature) and the vapour control orifice (which varies only with control knob setting).

Compensation for total flow variation is achieved by the design of the orifice elements which are precision parts.

Compensation for temperature variation (and therefore changes in vapour pressure, viscosity etc) is achieved by moving a needle valve within the bypass orifice to change its area, under the influence of a liquid-filled temperature sensitive device mounted within the vapour chamber so that it is exposed to both gas and liquid temperatures within the vaporizer.

Compensation for fluctuating back-pressure on the vaporizer, as produced by the use of IPPV in the breathing system is provided by the inclusion of a long narrow tube in the vapour chamber system which prevents reverse flow of vapour from the chamber into the bypass gas flow.

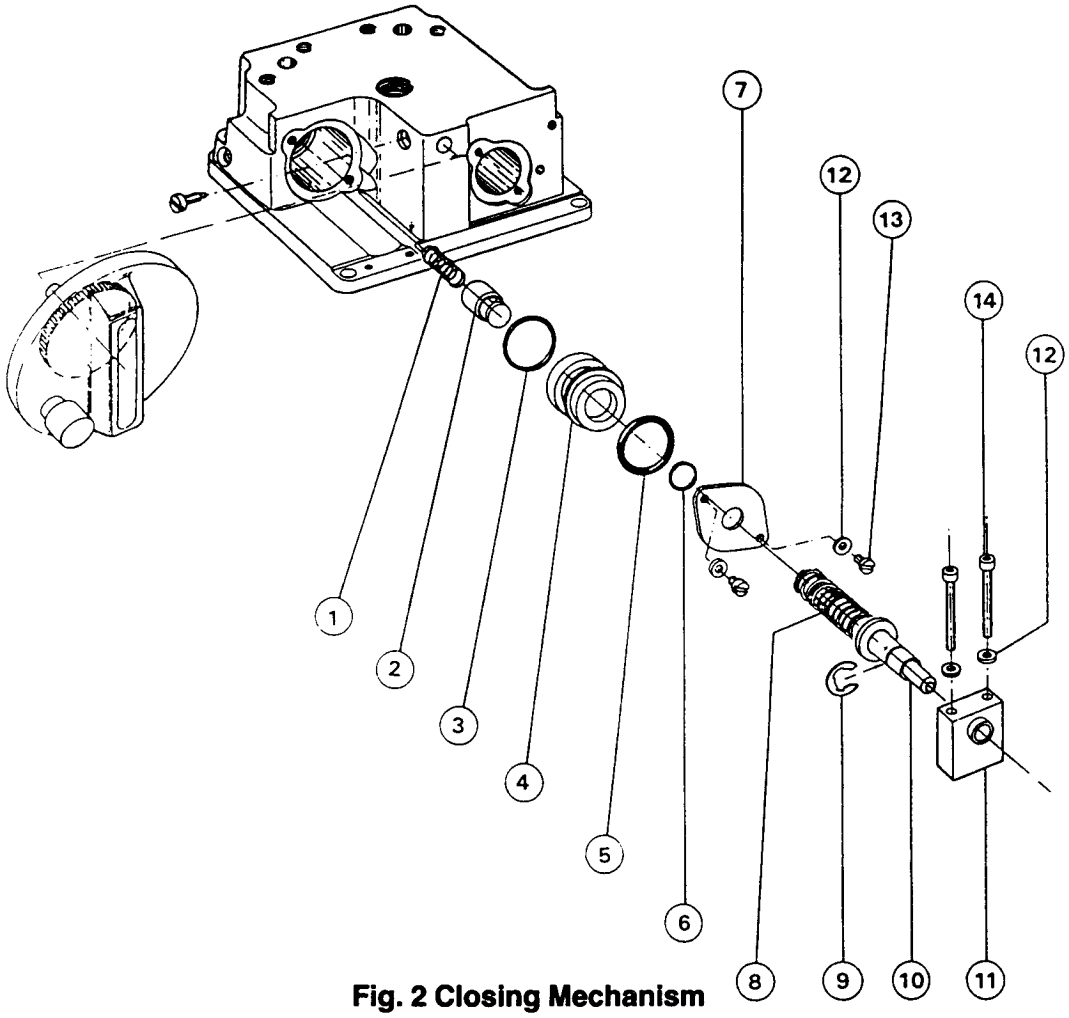


Fig. 2 Closing Mechanism

4.2 **Closing Mechanism** (Fig. 2)

The closing mechanism operates the zero lock port.
When the control knob is set to the '0' position, the zero lock button on the control knob aligns with a push rod. This push rod is spring loaded to enter the control knob and prevent further rotation.

The other end of the push rod is connected to a spring loaded valve which occludes the zero lock port preventing gas flow into the vapour chamber.

When the control knob zero lock button is pressed, the push rod opens the valve and when the knob has been turned to open the vapour control orifice, gas flows into and out of the vapour chamber (ref. 5.4/S3-5/6.6.7).

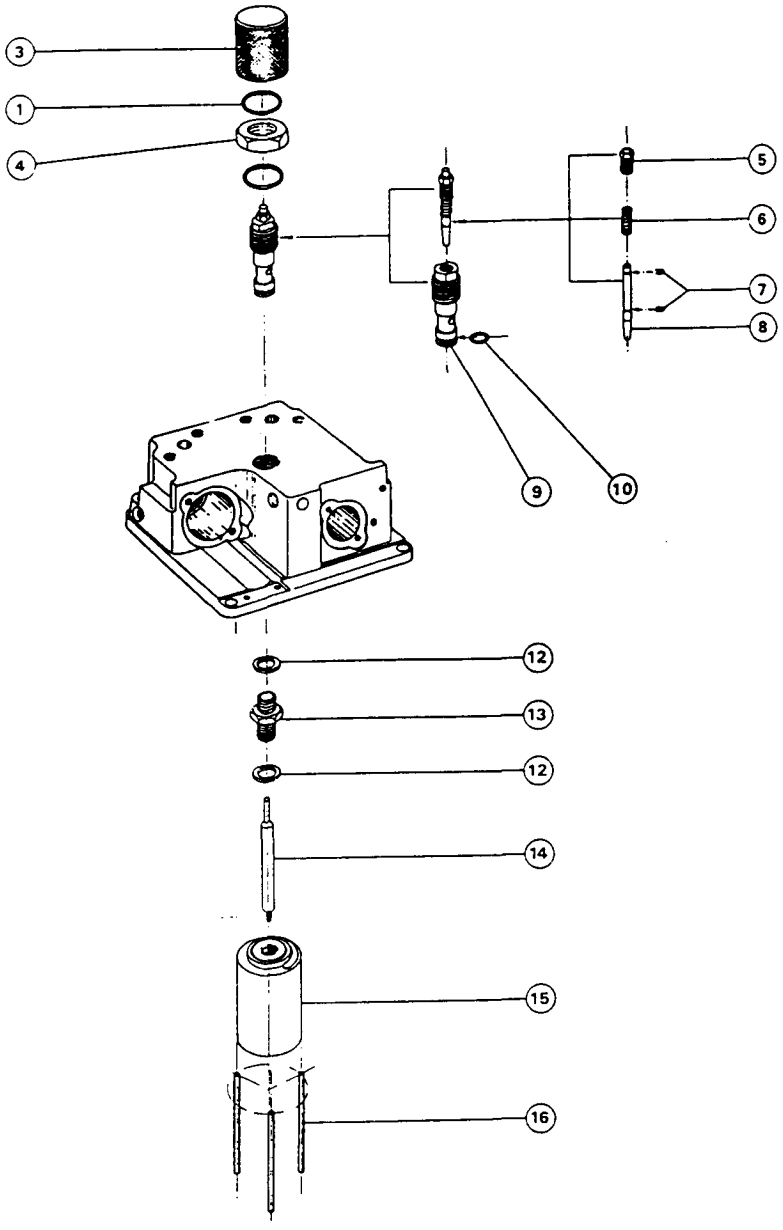


Fig. 3 Temperature Compensator

4.3 **Temperature Compensator** (Fig. 3)

The temperature sensitive element comprises a solid drawn metal sleeve brazed to an internal flexible metal bellows. The volume between the sleeve and the bellows is filled under vacuum with di-ethyl ether. Expansion and contraction of the liquid with change of temperature causes the bellows to expand and contract in a linear manner with great precision and reliability.

A push rod is attached to the inner end of the bellows and the outer sleeve of the temperature sensitive unit is connected to the body of the vaporizer. Movement of the push rod moves a spring-loaded tapered needle in the bypass orifice, so that bypass resistance to flow is increased at a low temperature, forcing more gas through the vapour chamber to compensate for the lower vapour pressure of the liquid. At high temperatures the bypass resistance is reduced by the reverse movement of the needle in the orifice.

Temperature compensator performance can be checked easily by measuring the bypass resistance to flow (ref. 5.3/S3-6/6.6.3).

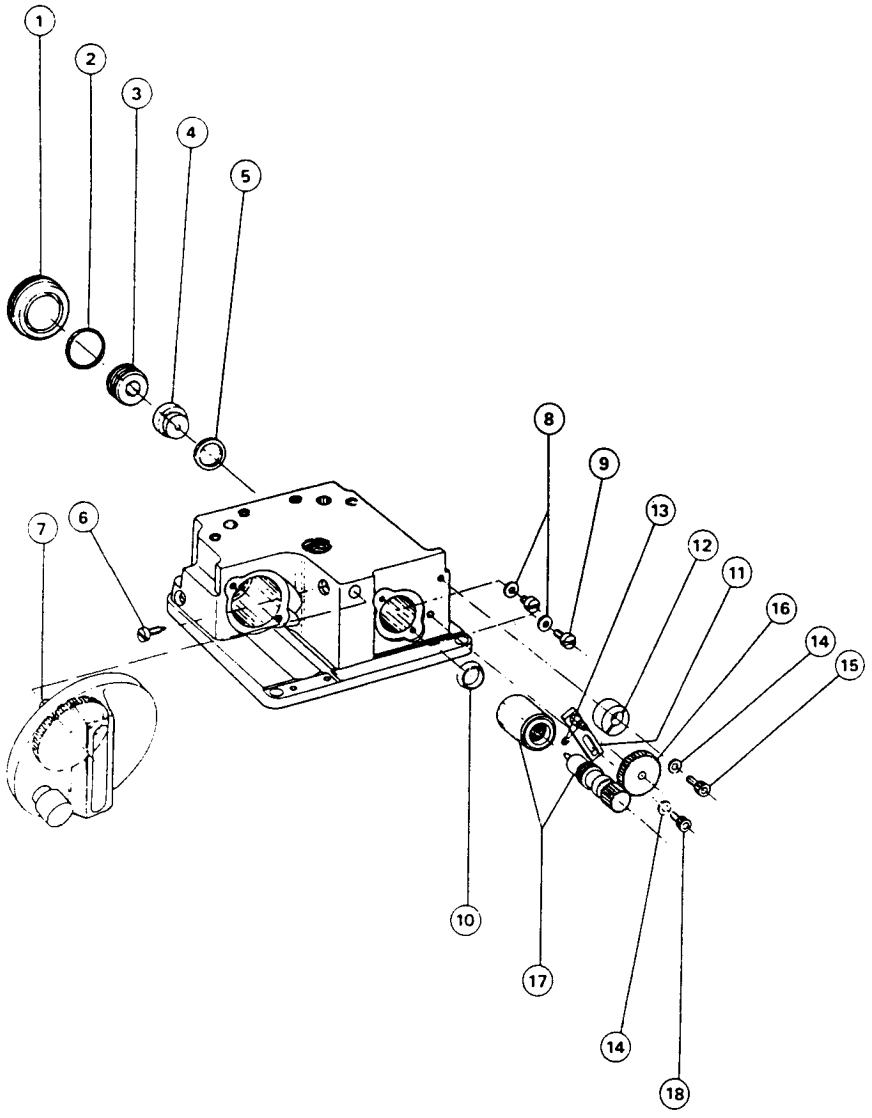


Fig. 4 Vapour Control Valve

4.4 **Vapour Control Valve** (Fig. 4)

This valve is a needle valve, operating in a sharp edged orifice, to give the concentration scale. The needle valve is attached to a threaded guide to advance and retard the needle relative to the seating (ref. 5.7/S5-12/6.6.4).

4.5 **Control Knob Assembly** (Fig. 2 and Fig. 4)

The outer end of the vapour control valve forms a spur gear which engages via an idler with a gear on the shaft of the control knob.

The control knob incorporates the zero lock button, and also stops, to prevent rotation beyond the working range in either direction.

'Click' indications of the major concentration points on the scale are provided by the zero lock push rod engaging into holes in the back of the control knob.

The rear of the control knob also operates the closing mechanism valve, where any radial action of the knob results in the valve shaft being driven forward to open the valve, whilst at zero the valve is closed when the shaft locates into the zero lock location hole.

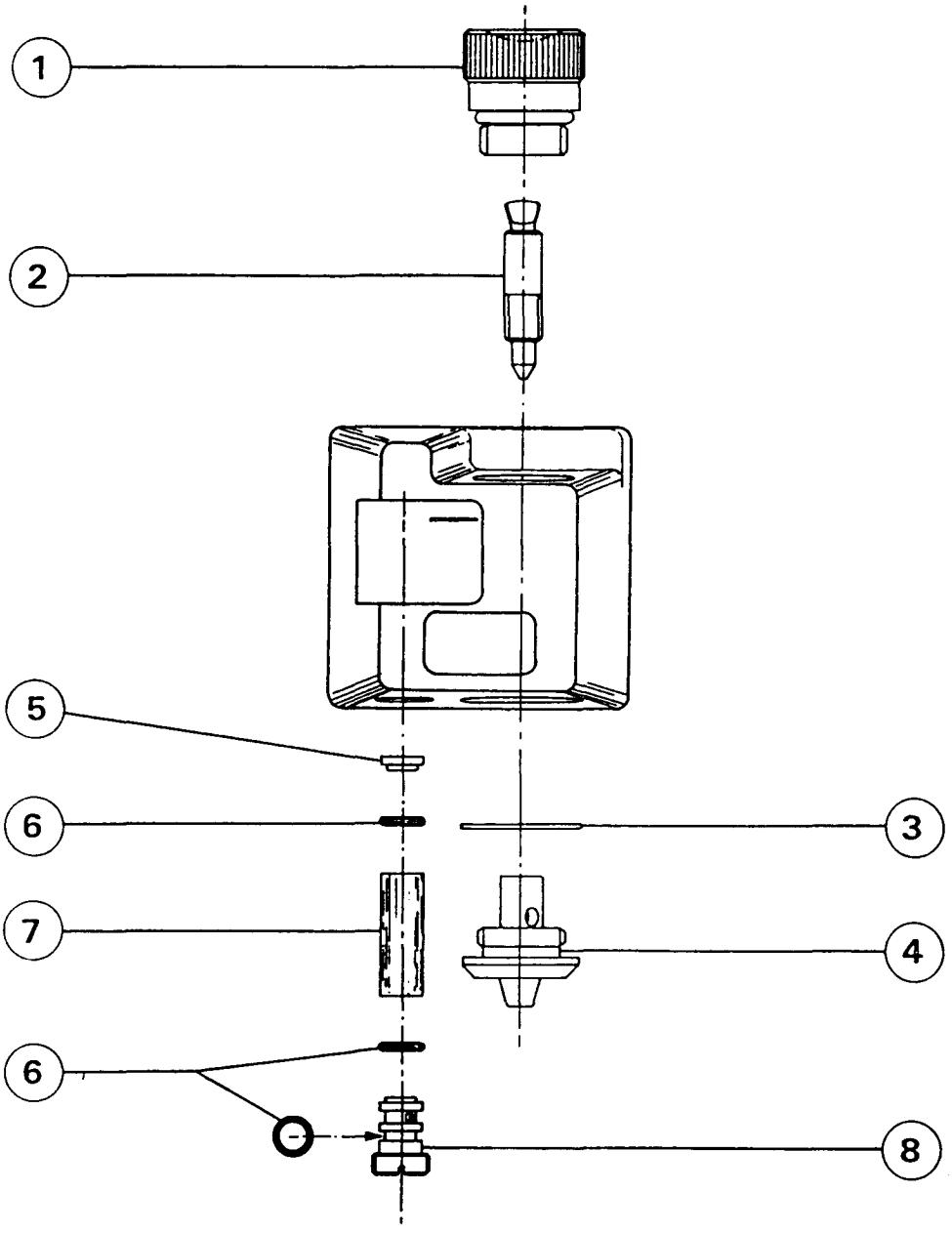


Fig. 5 Standard Filler

4.6 **Filler and Level Indicator (Standard type)** (Fig. 5)

This unit is bolted to the vaporizer body and provides a screw-plug sealed filler opening, with an internally mounted drain screw.

The level indicator is a glass tube, with a maximum level mark on the filler body. The minimum level is indicated by the lower edge of the level indicator aperture in the body.

Provided the vaporizer is upright, with the control knob set at '0', the chamber cannot be overfilled as the design of the air escape ports leads to air trapping at the maximum safe level.

A secondary safety feature, which comes into operation only if the level indicator is ignored, is the provision of a drain hole which will cause liquid to spill from the filler if excessive volume is poured in. (ref. 5.5/S3-7/6.6.8).

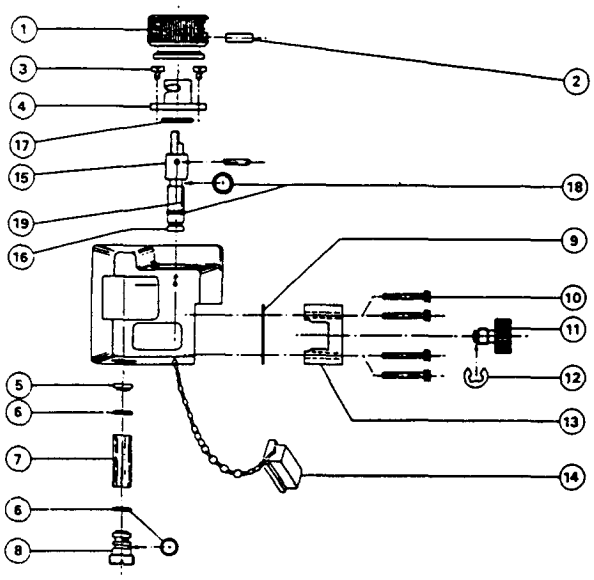


Fig. 6 Keyed Filler

4.7 **Filler and Level Indicator (Keyed Filler)** (Fig. 6)

This unit is fitted as an option to the standard type and is designed to be used with a bottle adaptor only. Operating instructions are included in the user's manual (ref. 5.6/S3-7/6.6.9).

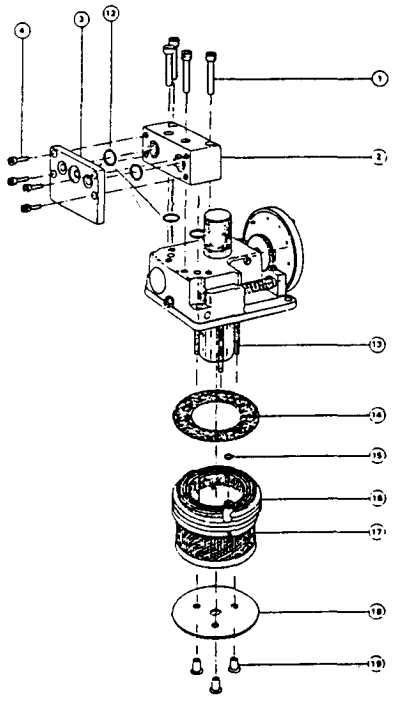


Fig. 7 Wick System

4.8 **Wick System** (Fig. 7)

The wick system consists of a long strip of stainless steel covered with specially woven stainless steel cloth, and rolled into a spiral. This is then clamped between two end plates to form an assembly which can be handled as a single unit, making replacement simple.

There are no wicks attached to the outer walls of the vapour chamber.

The spiral formation of the wick ensures that all gas passing through the vapour chamber has a passage approximately 1 metre long to follow. This permits vapour saturation to occur (ref. 5.2/S2.1-3/6.6.6).

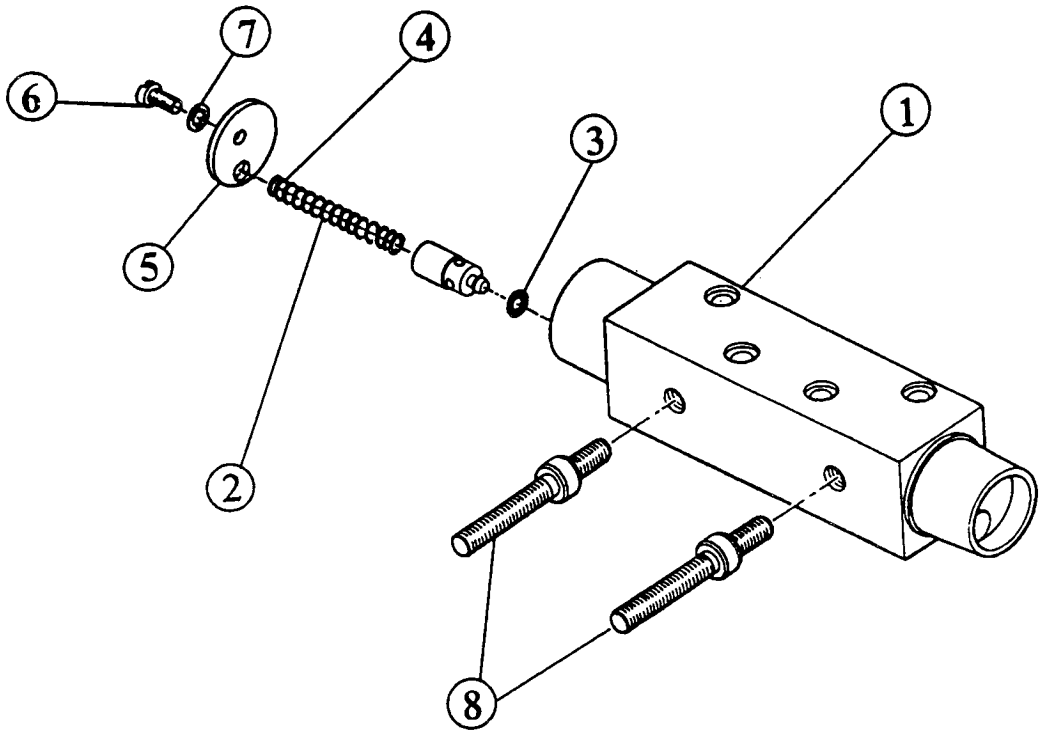


Fig. 8 Enflurane Connector Block

4.9 **Connector Block Pressure Relief Valve** (Fig. 8)
(Enflurane models only)

The connector block for most models of the PPV vaporizer consists of a solid brass block fitted with either rear entry connector ports for back bar attachment or cagemount tapers for 'off-line' use. The block is drilled to direct the flow of carrier gas directly into the valve block on which it is mounted, at which point the gas is redirected both through the bypass valve and vapour chamber.

On cagemount Enflurane models, the inlet and outlet ports of the connector block are joined by a drilled channel in which a pressure relief valve (PRV) is fitted in support of the requirements of ANSI Z79-8 1979. (Clause 13.1.13 and equivalent ISO 5368 clause).

The valve functions as a safety device, designed to operate in the event that the vaporizer has been incorrectly connected directly to a high flow source, i.e. the O_2 flush at the common gas outlet. The valve operates at a pressure of approximately 4 psi caused by a flow in excess of approximately 40 l/min, the action of which prevents the generation of high pressures likely to disturb the safe control of the vapour concentrations (ref. 5.9/S2-4/6.6.10).

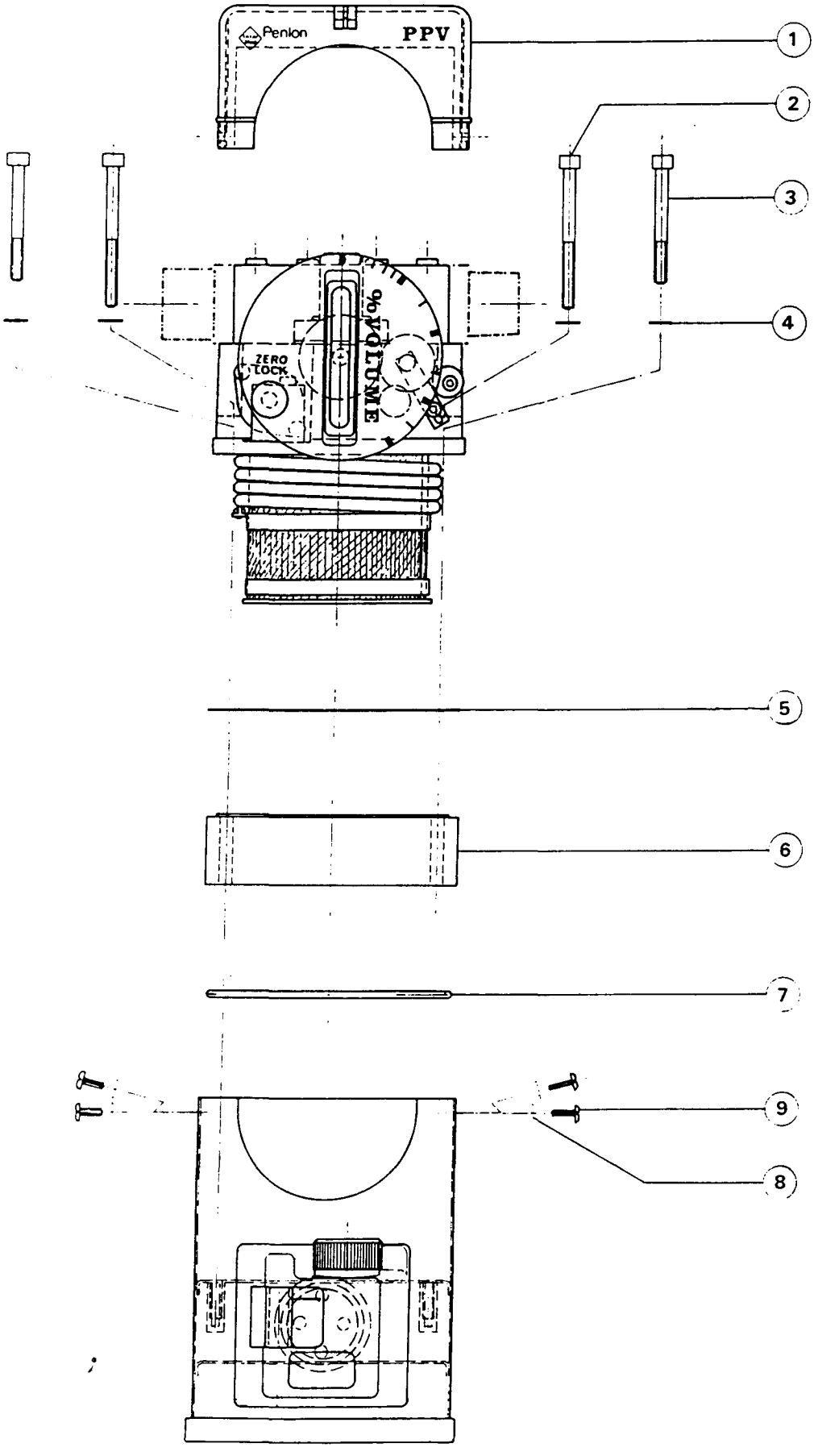


Fig. 9 Body Assembly

5. FAULT FINDING AND TEST

5.1 Concentration Output

For detailed failure of concentration output see calibration chart C2 and sub-section 6.6.1.

5.2 Wick Assembly (Fig. 7)

Loss of vaporizer concentrated output can mean poor wick performance, however this should not occur if the wick is maintained in a clean condition. The wick assembly must be changed at the end of 5 years service (see Chart 5Y-1) or if it becomes contaminated with dirt or thymol accumulation and will not readily respond to cleaning.

Follow the procedure in chart S2 (1-3) to remove the old wick and also refer to sub-section 6.6.6.

5.3 Temperature Compensator (Fig. 3)

Should the vaporizer performance become incorrect with changes of flow, or give high initial outputs which fall rapidly with use, then it is likely that the bypass resistance is out of adjustment.

Correction procedures are available in section 6.6.
a) Incorrect bypass resistance, 6.6.2.
b) Dismantling and rebuilding the temperature sensitive unit, 6.6.3.

5.4 Closing Mechanism (Fig. 2)

Leaks detected from the entry coil during operation 5 (Chart S3) indicate that the closing mechanism valve is not sealing. Before dismantling the unit check that it is not being held open by a fault in the control knob, by removing the control knob (Fig. 4, Item 7) completely from the body. This is affected by removing screw (Fig. 4, Item 6). Retest to see if the mechanism is now sealed. If so, the fault lies in the control knob setting. The position of the control knob onto the control shaft is critical as the rear face influences the opening and closing action of the closing mechanism valve, see sub-section 6.6.11. If the leak persists, see sub-section 6.6.7.

5.5 Level Indicator and Filler (Fig. 5 and 6)

The level indicator glass should be replaced if cracked or dirty. If leaks occur in the filler glass system, the seals should be replaced. Access to all components is from below, as shown in Fig. 5 and 6. If leaks develop between the filler block and vaporizer chamber, the interface seal should be replaced. Access to the fixing screws is readily obtained once the vaporizer body has been taken out of the vaporizing chamber, see sub-section 6.6.8.

5.6 Keyed Filler (Fig. 6)

Malfunction of the keyed filler system will normally show as inability to automatically fill within the time frame specified in the user manual. Failure can only be due to blockage of the ports due to debris or seal failure. The selector mechanism should be stripped and rebuilt according to the correction procedure in sub-section 6.6.9.

5.7 **Concentration Control** (Fig. 4)

Replacement of the concentration control needle or its bearing is indicated if there is excessive difference in output concentration between the upward and downward setting of the control knob and excessive backlash in the actual gear train is not present. Ref. C1 operation 5. There should be approximately 1 mm backlash measured at the dial circumference in a correctly adjusted gear train, see sub-section 6.6.4.

5.8 **Gear Train Setting**

If the incorrect amount of clearance is present on the vapour needle gear train, variations in vapour output may be experienced.

Disengage the closing mechanism valve shaft from contact with the rear of the control dial, using S.P. tool MH 615/35 and gently operate the control dial backwards and forwards. There should be approximately 1 mm backlash measured at the dial circumference in a correctly adjusted gear train, with a small amount of clearance at all gear contact points. Excessive clearance in the gear train will cause incorrect vapour output with upward and downward movement of the control dial.

Conversely, excessively tight adjustment will result in rapid wear of all the vapour valve components.

The torque required to move the control dial should not exceed 3.0 lbf in between the click stops over the complete range of the dial.

If adjustment to the gear train is required, refer to sub-section 6.6.5.

5.9 **Connector Block PRV** (Enflurane models only).

As referred to on Chart C2, if the connector block PRV leaks then the vaporizer will give a low output and the seals of the valve will need to be replaced.

To verify the correct function of the PRV, operate the following test procedure.

1. Remove the vaporizer lid.
2. Remove the temperature compensator (TC) sealing cap.
3. Remove the TC control needle by unscrewing the hexagon retaining nut. (Do not disturb the setting of the TC valve body).
4. Attach the TC blocking tool (MB 606/12)
5. Attach the vaporizer to test apparatus A.
6. Close the ventilator concentration control.
7. Slowly open the flow control to finally achieve 30 l/min, watching the pressure gauge at the same time.
   - Verify that the pressure relieves between 3-5 psi.
8. Cancel the flow and block the outlet of vaporizer.
9. Raise the pressure to 250 mm Hg then cancel the flow.
   - Verify that the pressure does not reduce to 200 mm Hg within 30 seconds.

To replace either the valve seals or to correct the pressure relief rate, refer to sub-section 6.6.10.

6. SERVICE PROCEDURES

6.1 Service Policy

It is essential that the output of the PPV should be checked regularly every 3-6 months, and that the vaporizer should be leak tested, as part of the overall servicing of the anaesthetic machine.

Results should be recorded in the service record book. Any departure from standard performance or a trend towards predicted failure, should be corrected by a service, carried out as described on charts C1 – C2. If the vaporizer is functioning correctly, no preventative maintenance is required.

After 5 years, certain additional components should be replaced as preventative maintenance in conjunction with a major service, if not performed earlier.

Details of the maintenance required after 5 years are given in chart 5Y-1.

6.2 Service Equipment

Equipment and tools required for test and servicing are as follows:–

6.2.1 Standard Equipment

Pressure regulator 0 – 60 psig.
Pressure regulator 0 – 400 cm H_2O.
Pressure gauge 0 – 250 mm Hg. 0 – 500 cm H_2O (0 – 50 kPa).
Flow meter unit 0 – 10 l/min.
Pressure isolating valve.
Leak detection fluid.
Torque screwdriver.
Gas analyser – The preferred form of analysis apparatus is an interferometer, but with suitable care to check the calibration, the following are also suitable:

Infrared analyser.
Ultra violet absorption meter (Halothane only)
Mass spectrometer.
Molecular absorption meter.

The selected analyser should have a sensitivity better than ± 0.1%.

6.2.2 Test Connectors and Equipment (available from Penlon)

Cagemount connection block (23100)
Pressure gauge tee connector (34226)
Flexible hose with cagemount female connector end (37019)
Blanking plug with pressure gauge connector (cagemount male 37018)
Nylon catheter (52605)
Exhaust tubing (breathing hose diameter) (57004)

6.2.3 Special Purpose Equipment (available from Penlon)

Peg spanner (M 615/30)
Closing mechanism tool (MH 615/35)
Vapour valve 'Bal Seal' loading tool (M 615/31)
Analyser mixing chamber (containing diffusion material) MH 561

6.2.4 Test Rigs

Layouts and test components are listed in the following pages.

Test Apparatus A – for flow checking and calibration check.

Test Apparatus B – for leak testing.

6.2.4.1 Test Apparatus A – for flow checking and calibration checks

TEST APPARATUS A

Comprises:

1 – Cagemount connection block (23160)

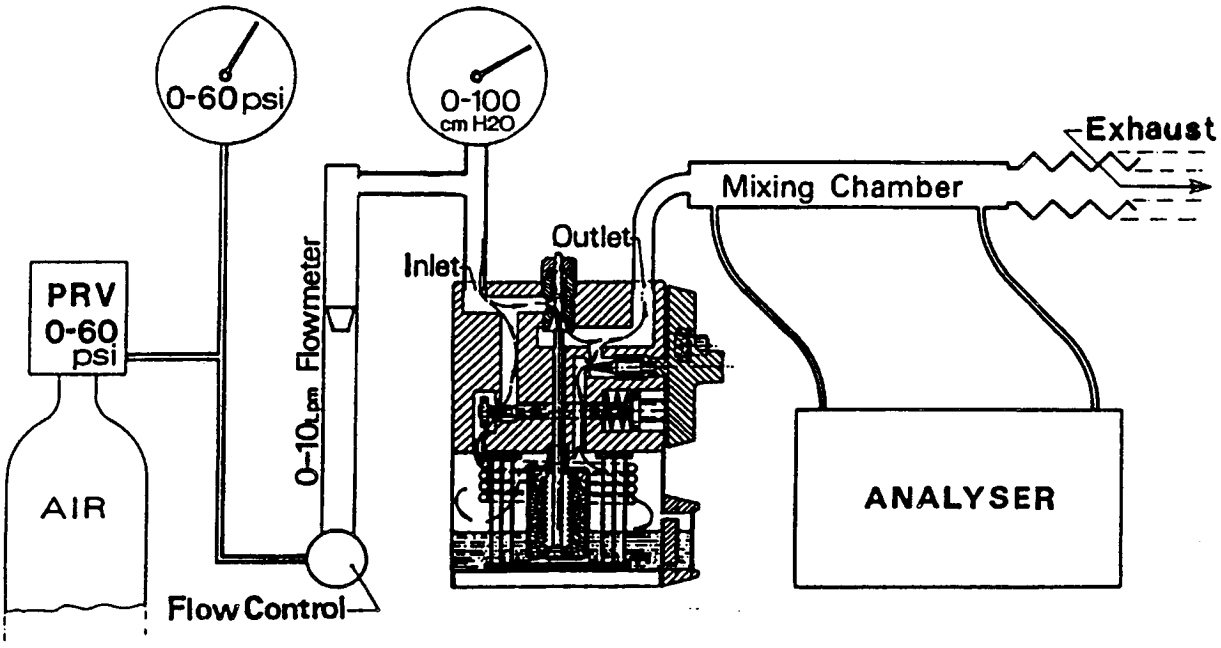
1 – Pressure regulator 0 – 60 psig

1 – Flowmeter unit 0 – 10 l/min

1 – Pressure gauge 0 – 100 cm H_2O

1 – Pressure gauge connector tee (34226)

NOTE While resistances are being measured, nothing must be attached to the outlet of the vaporizer.



6.2.4.2 Test Apparatus A – adapted for calibration

TEST APPARATUS A
– Adapted for Calibration

For use during calibration only, attach the following to the outlet of the vaporizer:

1 – Analyser mixing chamber (containing diffusing material) MH 561/1

1 – Nylon catheter to connect to analyser (52605)

Exhaust tubing (breathing hose diameter)

6.2.4.3 Test Apparatus B – for leak testing

TEST APPARATUS B

Comprises:

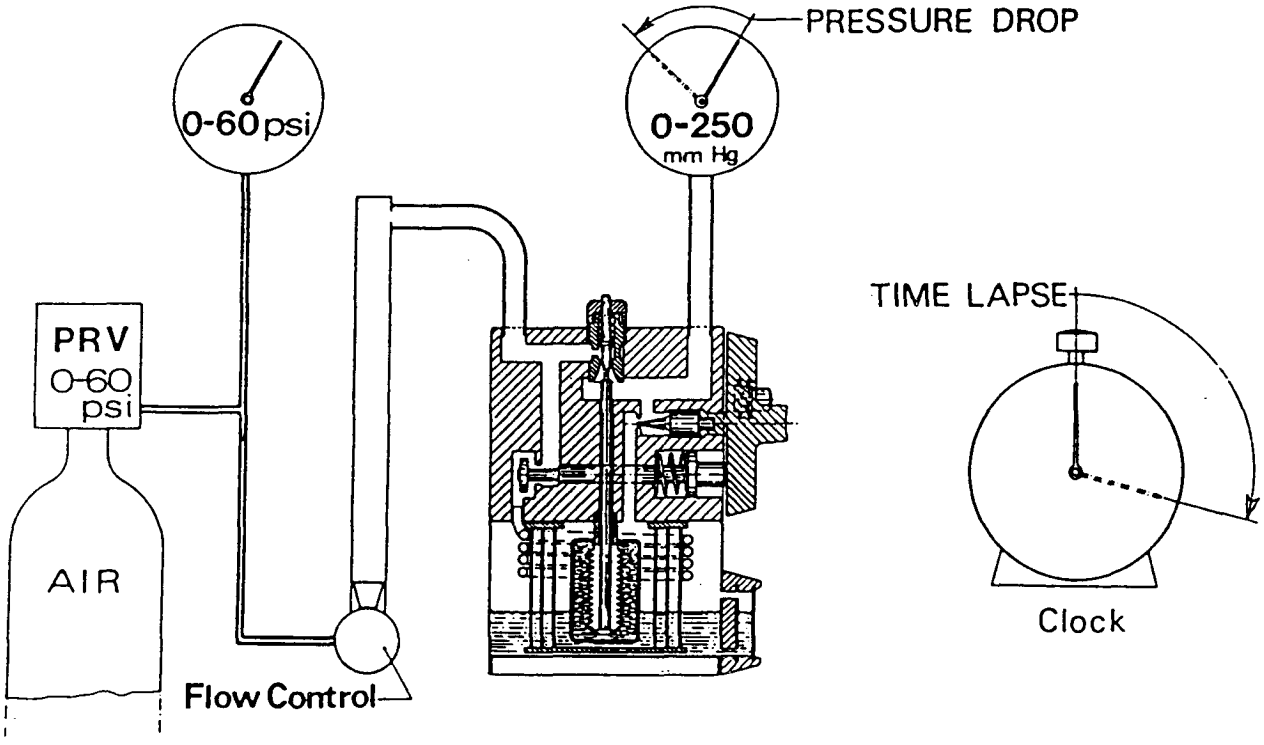
1 – Adjustable pressure regulator (max pressure 400 cm H_2O)

1 – On-Off flow control valve

1 – Flexible hose with cagemount female connector end (37019)

1 – Blanking plug with pressure gauge connector (cagemount male) (37018)

1 – Pressure gauge. 0 – 250 mm Hg is recommended.



6.3 **Calibration Check**

To be performed every 3 – 6 months

To include:

a) Draining of vaporizer.

b) Overall leak check.

c) Vaporizer refilling.

d) Concentration measurement – Chart C1.

e) Fault finding – Chart C2.

CHART C1

CALIBRATION CHECK – Refer 6.1. Time required 1 hour. Frequency 3–6 months			
Spares Required	Procedures (to be carried out with the vaporizer on the anaesthetic machine)	Test Values	Equipment
	NOTE: Anaesthetic gas scavenging equipment must be connected during these tests.		
	1. Agitate the anaesthetic agent in the vaporizer and then drain the vaporizer. Discard the contents and do not re-use. Close the filler system.		
	2. Verify the leak tightness of the anaesthetic machine.		
	3. Attach a pressure gauge to the common gas outlet of the machine.		
	Set one vaporizer at a time to ½ scale, with fillers shut.		
	Use the low flow flowmeter of the machine to raise the whole fresh gas system to 150 cm H_2O. Observe the reading on the low flow flowmeter required to maintain the system at 150 cm H_2O pressure.	Acceptance value 200 ml/min	
	REJECT ANY VAPORIZER SHOWING EXCESSIVE LEAKS AND REFER: Section 6. Fault correction.		
	4. Fill the vaporizers ¾ full with the correct agent. Allow 30 minutes for stabilization. Measure the output of the vaporizer with an approved analyser at the flows and outputs shown. Note the room temperature which must be within 20 – 22°C.	Test each unit at 2, 4 & 8 l/min and 1, 3 & 5% settings. Outputs should be within ± 20% of the indicated value. Record the actual value on the Test Sheet in the Service Record Book.	Test apparatus A with analyser and exhaust system
	5. REJECT ANY VAPORIZER SHOWING MORE THAN ±20% VARIANCE AND REFER TO FAULT FINDING CHART C2		

CHART C2

FAULT FINDING – Refer to chart C1 and Section 5			
Fault	Possible Cause	Treatment	References
1. Low or zero output at all flows and settings	(a) Insufficient liquid in chamber (b) Leak to atmosphere from vapour chamber (c) Closing mechanism not opening (d) Back bar PRV leaking (Enflurane models only)	(a) Refill/check level indicator (b) Fit new seals (c) Check position of control knob on shaft (d) Test back bar PRV for leaks, fit new seals as required.	Fig. 9 : Chart S2 Fig. 2 : 6.6.11 : 6.6.10
2. Low ouput at high flows only	(a) Contaminated wick (b) Leaking wick seals (c) Leak at start of entry tube	(a) Clean or replace wick. (b) Fit new seals (c) Fit new O-ring	Fig. 7 : 6.6.6 Fig. 7 : 6.6.6 Fig. 7 : Chart S2
3. High initial output falling rapidly with use	(a) Temperature compensator capsule faulty (b) Bypass out of adjustment NOTE: Trimming the bypass resistance within the specified tolerance values can usually bring calibrations within specification. (Ref. Chart S3, item 6).	(a) Replace TC capsule (b) Check resistance of bypass and adjust	Fig. 3 : 6.6.3 Fig. 3 : Chart S3 : 6.6.1
4. Excessive difference between output when adjusted clockwise or anticlockwise (backlash)	(a) Gear train out of adjustment (b) Worn needle valve or bearings.	(a) Adjust (b) Replace	Fig. 4 : 6.6.5 Fig. 4 : 6.6.4
5. Zero not obtained	(a) Incorrectly set or worn vapour needle and seat (b) Closing mechanism leaking (c) Leaks through TC assembly	(a) Adjust needle setting or replace needle and seat. (b) Replace seals (c) Replace seals	: 6.6.4 Fig. 2 : 6.6.7 Fig. 3 : 6.6.3

6.4 Major Service

To be performed if the calibration check indicates performance is departing from standard performance or is showing a trend towards predicted failure to specification.

To include:

a) internal cleaning

b) seal replacement, etc

c) rebuild procedures

d) leak testing

e) resistance testing

f) performance check

The vaporizer must be removed from the anaesthetic machine for these tests.

Details are given on charts S1 – S5.

CHART S1

MAJOR SERVICE – Time required 2 hours plus temperature stabilization time			
Spares Required	Procedures (to be carried out in the laboratory)	Test Values	Equipment/References
	NOTE: These procedures should be carried out in a room which has a stable temperature between 20 and 22°C not varying by more than ± 1°C over the test period. The vaporizer must be drained and dried out by passing an air flow of approx. 10 l/min through it until no vapour can be smelled at the exit. The vaporizer must in the stable temperature environment for 2 hours before bypass resistance figures are measured.		Temperature stabilised room Approx 1 sq. metre bench space Compressed air supply. Dry and clean, at 10 psi (approx 0.6 bar) Exhaust system for anaesthetic vapours. Test apparatus A (6.2.4) Test apparatus B (6.2.4) Analyser

CHART S2

MAJOR SERVICE			
Spares Required	Procedures	Test Values	Equipment/References
See Fig. 9	Preliminary Drain and dry out the vaporizer by passing an air stream through it with the control at maximum setting until no vapour can be smelled at outlet.		Test apparatus A Exhaust system Compressed air supply
	1. Remove the cap (4 fixing screws)		Screwdriver
2–042806	2. Remove the 4 fixing screws (rear 0530, front 019702). Retain the screws and washer. Lift the control mechanism out of the chamber. Discard the seal (23046) and replace with (042806). Lift out the distance piece, discard the seal and replace.		4 mm hexagon key
See Fig. 7 1–041103 1–23044	3. Remove the wick fixing nuts. Lift out the wick and entry tube. Discard the O-seal on the entry tube and replace (Item 15) Discard the wick gasket and replace (Item 14)		6 mm screwdriver
1–23160 2–041107 (Cagemount model) 4–041107 (Back entry model)	4. Remove the inlet connection block if the unit is back entry and fit the special servicing block. or Discard the O-seals on the cagemount connector block and replace (Item 12) (On enflurane models change the PRV seal) You now have the control mechanism, without wicks or inlet spiral tube, with the servicing connector block attached if unit is back entry. Put aside the vapour chamber and other parts until operation 7.		4 mm hexagon key 6.6.10

CHART S3

MAJOR SERVICE

Spares Required	Procedures	Test Values	Equipment/References
	5. Connect the inlet to test apparatus B. Block the outlet and vapour port. Open the control knob and pressurise to 150 mm Hg and turn off the air supply. This tests for leaks through the closing mechanism, TC cap and vapour control needle bearing. IF LEAKS OCCUR SEE SECTION 6.6 AND CORRECT BEFORE PROCEEDING FURTHER.	Measure the time for the pressure to drop. Pass if value greater than 60s to 50% pressure.	Test apparatus B. Leak detection fluid
	6. Connect the inlet to test apparatus A. Set the control knob to zero. Check that the unit has been in a stable temperature condition for at least 2 hours. Read the thermometer and measure the resistance to gas flow through the bypass at various flows. Compare with table. Values should be within 20% of those shown or interpolated values if at intermediate temperatures. IF RESULTS INCORRECT SEE SUB-SECTION 6.6.2 AND CORRECT BEFORE PROCEEDING FURTHER.	Bypass resistance cm H_2O 2 l/min / 4 l/min / 8 l/min 16°C: 4.2 / 13.6 / 47.1 20°C: 3.3 / 10.4 / 35.2 24°C: 2.6 / 8.4 / 28.3 28°C: 2.0 / 6.6 / 23.0	Test apparatus A.
See Fig. 5 & 6 3–0314	7. Examine the vaporizing chamber and clean internally. Check that the level indicator glass is clean and intact. Replace the seals on the level indicator glass and keyed filler system if fitted.		6.6.8 6.6.9

CHART S4

MAJOR SERVICE			
Spares Required	Procedure	Test Values	Equipment/References
See Fig. 4	8. Check the tightness of all fixing screws on the body assembly. Check the gear assembly for backlash and if necessary adjust the idler gear.		6.6.5
	9. Reassemble the parts to the vapour chamber using new seals for: (a) Wick and entry tube (Fig. 7) (b) Distance piece and body to chamber (Fig. 9)		Test apparatus B
2–042806	Extra assembly instructions: Vapour chamber seal replacement, applicable to all units manufacturered before May '87 – Replace Part No. 23046 (item 5 Fig. 9) with 042806 (item 7 Fig. 9) and assemble with 4 spacer washers Part No. 23054 fitted between the distance piece (item 6 fig. 9) and the valve block assembly. Retain these spacer washers over the fixing holes with a small amount of Fomblin grease to stop misalignment during the lowering of the valve block assembly into the vapour chamber.		
	10. Tighten the main fixing screws (2) – (3) Fig. 9 with a torque controlled driver to a value of 15 lbf ft Connect to test apparatus B and leak test with the knob at mid position pressure to 200 mm Hg and turn off the air supply. This tests the main seals between the chamber and the control mechanism.	Measure the time for the pressure to drop. Pass if value 60s to 90% of pressure.	Test apparatus B

CHART S5

MAJOR SERVICE			
Spares Required	Procedure	Test Values	Equipment/References
See Fig. 9	11. Replace the cap on the vaporizer (check colour coding). Item 1.		Test apparatus A
Fig. 4	12. Fill to mid level with required anaesthetic agent. Allow to stand 30 minutes, then check calibration at flows of 2, 4 and 8 l/min. FOR A CORRECT PERFORMANCE ALL MEASURED VALUES SHOULD BE WITHIN 20% OF THE SCALE SETTING. The key figure is 1% setting at 4 l/min. If this is incorrect remove the cap from the vaporizer, and remove the complete knob assembly by undoing screw 6.		Analyser Exhaust system
Fig. 2	Hold the closing mechanism open by pressure on plunger, item 10, and turn the needle valve slowly until a true 1% reading is obtained on the analyser at 4 l/min flow. Carefuly re-engage the knob assembly so that the '1' graduation lines up with the index on the cap. Refit and tighten screw, item 6. Check all other calibration points. Re-adjust if necessary by steps of 1 tooth on the gear train.		
	13. Drain and dry out the vaporizer.		
	14. Complete service records.		
	15. Return to service, with 'Just Serviced' label attached.		

6.4.1 Sequence Guide to Major Service

Drain, dry out and record serial no., date etc.

START

Remove the cover, gas connector block, (back entry only) main fixing screws (items 1 – 4 Fig. 9)

Lift out the control mechanism, spacer and seals (items 5 – 7 Fig. 9)

Vapour Chamber. Examine for corrosion and dirt. Scrap if corroded. Wash out if dirty.

Level Indicator and Filler (Fig. 5 and 6). Examine the tube and replace the seals.

Hold the control mechanism and remove the inlet tube and wick unit (item 16 and 17 Fig. 7). Scrap and replace the seals. Wash in ether or equivalent solvent if dirty.

Assemble the service gas connector block (back entry only).

Leak test (Chart S3, operation 5).

Stabilize temperature at 20°C (1 hour)

(A) Measure the bypass resistance (Chart S3, item 6) and record.
Compare with standard. Adjust if necessary.

Reassemble the wick and inlet tube.

Reassemble the unit to the vapour chamber with new seals (chart S4, operation 9).

Leak test (Chart S4, operation 10).

Check mechanical parts of control knob (Fig. 2 and 4).

Fill ½ full and hold (2 hours).*

Calibrate (Chart C1, operation 4) if incorrect, repeat from (A) (refer chart C2).

Drain, dry-out. Record Results. Return to User.

* If filled with temperature stabilized agent, the time can be reduced to 30 minutes.

6.5 5 Year Overhaul

After 5 years certain components should be replaced as preventative maintenance, and a major service must also be performed, if not performed earlier.

Details are given in chart form (Chart 5Y-1 following)

CHART 5Y-1

5 YEAR OVERHAUL			
Spares Required	Procedures	Test Values	Equipment
See Fig. 2–9	Follow major service procedure, but in addition:		
1–23023	1. Discard and replace the wick assembly		
1–22620 2–042805 Seal	2. Discard and replace the temperature sensitive unit assembly and fit new copper seals. Pay special attention to leak testing this joint, as described in 6.6.3. Note: To remove the existing temperature sensitive unit use two-hole pliers with a leather strap lining the jaws and grip the temperature sensitive unit at the end nearest to the vaporizer body.		
	3. Discard and replace all O-rings in the closing mechanism and the rear plug.		
	4. Replace the PTFE seals in the keyed filler unit.		

6.6 Fault Correction

6.6.1 Incorrect Concentration Output

Following the disturbance of the vaporizer through routine service, it may well be that even after obtaining the correct control settings and bypass resistance, the vaporizer will not perform on all dial settings within the required ± 20% tolerance band.

Upper scale inaccuracies

Chart S3 operation 6 shows a table of bypass resistances measured against a variety of flows. A latitude of ± 20% can be tolerated on these values and use of this flexibility can be made to 'trim' the vaporizer to within correct working tolerances.

The best value for trimming the vaporizer is at 4 l/min flow at a steady temperature of 20°C at which the bypass resistance value is nominally 10.4 cm H_2O. Should the vaporizer be inaccurate at the upper scale settings, adjustment of the bypass resistance *down* towards the lower limit (i.e. 10.4 – 20% = 8.3 cm H_2O) will result in a small *reduction* of the upper scale concentration whilst the lower scale range remains unaltered.

Conversely the opposite applies in that an increment in bypass resistance (within tolerance) will cause the upper scale values to slightly lift.

Lower scale inaccuracies

Should the vaporizer be inaccurate at the lower scale settings, then corrections must be made through gear tooth adjustment of the control mechanism. By withdrawing the control knob shaft and gear assembly (as described in 6.6.4) re-engage the gear train by intervals of one tooth up or down. To affect the lower scale concentrations; increase the needle penetration by one tooth to reduce the performance and decrease by one to increase.

NOTE In the event of needle adjustment, care must be taken not to exceed the zero engagement torque of 80 ozf in. To exceed this value could bring about over engagement of the needle and seat resulting in premature wear and failure of the vaporizer.

Through the correct balance of bypass and concentration needle adjustment, most concentration inaccuracies can be corrected. Should the vaporizer not respond, however, care must be taken to ensure the vaporizer is stabilized at the correct temperature before repeating the adjustment procedure.

NOTE If difficulty is still experienced obtaining adequate calibration the vaporizer must be returned to Penlon Ltd. for re-calibration.

6.6.2 Adjustment of Bypass Resistance

To adjust the bypass valve, connect the vaporizer to test apparatus A as shown in sub-section 6.2.4.1. Remove the TC cover to expose the valve and its lock nut. Release the lock nut and, referring to chart S3 operation 6, adjust the valve bobbin by use of the spanner flats until the values shown in the table are obtained.

Ensure at all times that the vaporizer has stabilized to the correct temperature and verify that the indicator measures from 0.175 in – 0.235 in showing correct capsule function.

In the event that the bypass valve will not adjust, there is a possibility of a premature failure of the temperature sensitive unit which will produce a higher than normal resistance. If this is suspected, check the resistance at two different temperatures (say 18°C and 28°C). If one reading is correct and the other incorrect, the TC unit must be replaced (refer 6.6.3. Temperature Compensator).

6.6.3 Dismantling and Rebuilding the Temperature Sensitive Unit (see Fig. 3)

Incorrect bypass resistance figures may require that the temperature compensator is completely dismantled. Start by following the procedure of chart S2 (1–4) unless already performed.

Remove the TC cap (3)

Unscrew the spring retainer (5), remove the needle and spring (6 and 8).
Check that the needle moves freely in the retainer and the spring is securely retained on the needle by the 2 circlips (7).

Loosen the 12 mm lock nut and unscrew the TC bobbin (4, 9 and 10).
Check for cleanliness and replace the O-ring (10).
Lay aside together with the TC cap.

Hold the TC connector (13), 0.6 in (15.2 mm) A/F spanner.
Grip the end of the temperature sensitive unit nearest to the body with leather lined pliers and unscrew. (Note that the upper flanged end is the only part of the temperature sensitive unit strong enough to resist the pressure of a wrench or pliers).

Discard the copper sealing washer (12) and use a new washer when reassembling the unit.

The temperature sensitive unit has a push rod attached to its interior. Gentle pushing or pulling of this rod should not produce movement, if axial movement is easy to produce the temperature sensitive unit must be replaced.

If a temperature controlled water bath is available, the movement with temperature of the push rod may be tested between two temperatures (maximum 40°C, minimum 4°C) and it should be 0.009 in (0.23 mm) per °C temperature change.

The push rod (14) can be detached from the temperature sensitive unit by turning it anti-clockwise. Great care must be taken when fitting a push rod to the temperature sensitive unit to ensure that the threaded end is accurately engaged in the thread provided and not lodged between the bush and the bellows in the interior of the temperature sensitive unit.

Reassemble in the reverse order.
Refer to chart S3 operation 6 and 6.6.2 for correct adjustment of bypass resistance.

6.6.4 Concentration Control (see Fig. 4)

1. Following diagnosis from chart C2 operation 4, that a worn needle valve or bearing will need replacement, then both items must always be replaced as a pair. To protect the function of the concentration control valve, it is most important that during the process of replacement the needle is not screwed into the seat.

To change the concentration needle and bearing, the control mechanism unit must be removed from the vapour chamber (ref. chart S2 operation 1–2).

Set the concentration control with the bar precisely horizontal.

Remove the retaining screw (5) and pull out the knob shaft and gear assembly, without rotation. **DO NOT** remove the knob by loosening the clamp screw accessible through one end of the finger bar.

As the control knob has been turned 90° from 0°, the needle valve is 270° (¾ of a turn) from the closed position.
Slacken the adjusting cam (12) and set it wide open.
Slacken the idler gear assembly by one turn on screw (15) and disengage the idler gear (early models).
Remove the idler gear assembly by removing two screws (later models).

Remove the two retaining screws (9) and extract the needle valve and its guide by a straight pull (do not twist). Record the projection length of the needle tip from the guide and note the orientation of the bush to ensure replacement is identical.

Only the complete needle and bearing assembly is available as a spare part (Fig. 4 Item 17) and before fitting a new unit the projection length of the new needle from the guide should be set to the same value as for the needle removed from the vaporizer.

WARNING **Needle designs vary with agent and maximum concentration. Spare needle assemblies are labelled but the service engineer must accept full responsibility for fitting the correct replacement needle to each vaporizer.**

Reassemble the pre-set needle and guide assembly to the control mechanism body, making sure to locate the clamp washers into 'cut outs' in the needle bearing in the same attitude as prior to removal.

NOTE On models manufactured since January 1989, a spring has been fitted to locate over the concentration needle, the action of which is to assist the needle in the accurate control of vapour concentration. Prior to the final securing of the control drive mechanism, unscrew the needle, insert the spring into the needle housing ensuring correct location over the seat guide. Refit the needle and ensure the location of the needle into the spring.

Reassemble the control mechanism into the vaporizer without the control knob assembly. Leak test the chamber joint using test apparatus B (see S4-9)

Fill the vaporizer with the appropriate agent (½-¾ full).
Allow to equilibriate for 30 minutes. Connect the unit to test apparatus A with analyser.
Turn on a flow of 4 l/min. Hold open the closing mechanism by pressing on its plunger. Using fingers on the geared end of the control needle, adjust the needle until 1.0% is shown on the analyser.

Fit the cover loosely in position and slide the control knob into position so that the '1%' mark is aligned with the indicator on the cover. Avoid rotating the knob until the gear train has engaged.

Remove the cover, press the control knob fully home, precisely in the 1% position, and lock it in position by inserting and tightening screw 5. Ensure that the knob is opening the closing mechanism at this position. Adjust the gear train as set out in 6.6.5.

Check output at all other points on the scale, and at zero.
If adjustment is necessary, follow the correction procedure 6.6.1.

The acceptance level at 4 l/min is ± 20% of any point on the scale that is calibrated.

NOTE If, following procedure 6.6.4, accuracy of scale cannot be achieved, then the vaporizer must be returned to Penlon Ltd. for re-calibration.

2. Vapour Seat (Fig. 4)

Symptoms of failure of the vapour seat are mentioned in Chart C2 operation 5, normally resulting in extreme difficulty to calibrate back to the original dial settings. Damage or wear to the seat will always be in conjunction to damage to the needle and both components must be replaced at the same time and most likely at the five year service. Prior to work beginning on the vapour seat the needle and bearing must be removed as access must be gained from two directions to successfully change a valve seat. (For needle and bearing removal see 6.6.4).

Referring to fig. 4, access to the vapour valve seat is from the rear of the valve block. Using special peg spanner M615/30 remove blanking plug (1) to expose the vapour valve seat retainer (3).

Remove the seat retainer using a ¼ in AF hexagon key, after which the vapour valve seat will dislodge from its location. Removal is from the rear and on early models the seating may need to be displaced by tapping it with a soft dowel from the front.

Replace the new seat as follows:

Insert the new seat into position from the rear, ensuring correct orientation and lightly retain using the seat retainer. Back off the retainer two full turns.

Fully retract the needle in the needle bearing and load the needle assembly into the body, ensuring that the cut-outs in the needle assembly are aligned with the screw holes in the valve block.

With the rear of the valve block facing upwards, wind in the needle gently until the needle and the seat come into contact with the seat retainer. Secure the seat retainer into position allowing the needle to come forward freely.

Unwind the needle away from seat and tighten the seat retainer to a torque of 5 lbf ft.

Looking down onto the seat from the rear, verify needle and seat concentricity by screwing the needle in and out. Refit the blanking plug.

Secure the needle assembly and reassemble the remainder of the vaporizer control mechanism following 6.6.4.

6.6.5 Adjustment of Gear Train (Fig. 4)

Detailed instructions for the procedure are as follows:

Early Models: (prior to May 1987)

Hold the idler gear into engagement with the knob gear and needle pinion and tighten the idler gear screw (18). Check that there is a small amount of backlash on all gear contacts to not exceed 1° rotation at the dial. Position the cam (11) so that it is in contact with the idler arm and tighten the screw (15). Recheck the gear assembly.

Later Models:

Reassemble the idler plate engaging idler gear to the nearest possible gear location. Locate with two screws and tighten the screws whilst holding the idler gear into engagement with the knob gear and the needle pinion.

Check that there is a small amount of backlash on all gear contacts to not exceed 1° rotation at the dial.

NOTE Over tightening of the gear train will lead to premature wear, and also cause excessive stiffness of the control knob.

Check the torque required to move the control dial. This should be between 2 and 3 lbf in between the click stops over the complete range of the dial.

6.6.6 Wick Assembly (Fig. 7)

The wick assembly must be changed if it becomes contaminated with dust, thymol accumulation etc.
Follow the procedure of chart S2 (1-3) to remove the old wick.

This must be replaced with a new assembly. When fitting the new wick always use a new cloth gasket (14) and ensure that all upper edges of the wick are covered by this gasket. The wick should be fitted so that the outer entry to the spiral formation is adjacent to the lower end of the entry coil tubing.

Secure the new wick by reversing the procedure in chart S2. Ensure the three retaining nuts are correctly tightened.

NOTE Wear gloves when handling the wick. Finger grease can impair wick efficiency.

6.6.7 Leaks in the Closing Mechanism (Fig. 2)

Remove the guide block (11) by undoing the screws (14) and take off the push rod assembly with the spring etc. Lay aside.

Remove the 2 screws and washers (12, 13), withdraw the cover plate (7) to obtain access to the seal bobbin (4).

It is best to use air pressure to extract this component which must not be distorted or damaged by mishandling.

The valve and plunger assembly (2) is then accessible.

If the seat face is damaged or the unit is dirty, it should be replaced taking great care not to damage the finely machined face of the PTFE seal. New O-rings should be used when reassembling the seal bobbin (3, 5), and care must be taken to avoid distorting the seals, by overtightening one side of the retaining plate before the other. The retaining plate should be finally located flat onto the valve body.

The push rod (10) should be lightly lubricated with a PTFE based grease before reassembling. Retest after assembly, using test 5 (Chart S3).

Leaks through the cover plate of the closing mechanism are due to faulty O-rings or the Bal-Seal (6) round the push rod. These seals should be replaced as required.

6.6.8 Leaks in the Filler Block (Fig. 5 and 6)

Sight Glass

Drain the vaporizer (refer chart S1)

Invert the vaporizer and remove the white plastic plug from the base of the filler block by unscrewing in an anti-clockwise direction.

Withdraw the plug which carries the lower seal.

Remove the lower sight glass.

Withdraw the sight glass using gentle sideways action to release.

Remove the sight glass upper locator and attached seal.

Clean all internal areas of the filler block using methylated spirits agitated by a small bush.

Thoroughly dry all parts.

Clean the upper and lower seal carriers and replace all seals.

Reassemble in the reverse order.

Take care to ensure the seal carriers are located into the filler glass and that the seals are correctly located on the ends of the sight glass.

Tighten the lower seal carrier to a torque of 4 lbf in.

Filler Cap

Replacement seals for the filler cap are not available separately. Complete filler caps are provided with service kit K1-S.

Replace the filler cap and leak test the vaporizer by following Chart C1. (1-4).

If the leak persists, examine the surface of the filler block seal for damage, replace the complete block if required.

Access to the block fixing is from inside the vapour chamber. To remove and replace the block, follow the service procedure charts S2 – S5 (as appropriate) for correct dismantling and rebuilding the vaporizer. Ensure that on completion of the repair the vaporizer is leak checked followed by function checking.

6.6.9 Keyed Filler Malfunction (see Fig. 6)

Replacing the seals in the keyed filler system will restore the efficiency of the automatic filling system if difficulty is being experienced. (Ref. 5.6 and Chart 5Y-1, operation 4).

Replacement of the seals can only be performed through the complete replacement of the filler valve assembly.

Ensure that the vaporizer is empty of liquid agent.

Referring to Fig. 6, release the two 2 mm grub screws and remove the knob (1) from the filler unit.

Remove the four screws (3) securing the filler valve assembly to the filler body.

Remove the complete filler valve assembly and discard.

Examine the filler block chamber for signs of debris and ensure the area is completely clean before progressing.

Refit the new filler valve assembly. Check that the valve has been fully retracted by turning anti-clockwise in cam plate (4) before insertion. Replace and tighten the four screws (3).

Re-attach the knob (1).

Open the vaporizer concentration control and leak test the vaporizer, see Chart C1, 1-4.

Fill the vaporizer and time the filling process from empty to 'MAX'. This should not be greater than 2 minutes.

Drain the contents of vaporizer into an empty agent bottle and transfer to a measuring cylinder; the volume should be 165 ml ± 20 ml.

The detailed procedure for filling and emptying the vaporizer may be found in Section 6 of the user's instruction manual.

6.6.10 Enflurane Connector Block (see Fig. 8)

In the event of a detected leak or PRV malfunction on the enflurane back bar, the following correction procedure applies:

Remove the vaporizer lid on back entry models only.
Remove the retaining screw located either in the cagemount outlet connector or on the outlet side of the back entry model.

Remove the spring retaining plate and withdraw the spring and valve plunger.

Replace the seal on the valve plunger and the spring if the PRV relief pressure is suspect.

Reassemble in the reverse order. Ensure the correct orientation of the retention plate on the cagemount model.

Verify the correct working performance of the back bar PRV by following test procedures as defined in 5.9.

6.6.11 Control Knob Setting (see Fig. 4)

The control knob is attached to the control shaft with a lockable 3 mm grub screw located in the control knob thumb bar. The grub screw drives onto a cylinderical slug which locates onto a prepared flat on the control shaft. The control knob and shaft can be firmly locked together and always in the same radial location.

Adjustment is possible however, along the length of the shaft, to influence the action of the closing mechanism valve.

To ensure the correct position of the control knob, open the control such that the thumb bar is in the horizontal position. Loosen the 3 mm grub screw and place a 0.020 in feeler gauge between the control knob rear face and the vaporizer body (not the plastic cap). Press the control knob towards the body to hold the feeler gauge and tighten the grub screw.

Verify the clearance remains within 0.015 – 0.025 in.

7. SPARE PARTS LIST

Major Servicing Kit (Standard Filler Models) (K1-S) 23210

Comprises:

2 Body Seals	042806
1 Filler Cap and Seal	22729
3 Level Indicator Glass Seals	041202
1 'O'-Seal for entry coil	041103
4 Outlet Block Seals	041107
1 Wick Sealing Washer	23044

— Major Servicing Kit (Keyed Filler Models) (K1–K) 23211

Comprises:

2 Body Seals	042806
1 Keyed Filler Gasket	22550
3 Level Indicator Glass Seals	041202
1 'O'-Seal for entry coil	041103
4 Outlet Block Seals	041107
1 Wick Sealing Washer	23044

For 5 year overhaul, use one of the above plus 5 year kit (K5) 23212

1 Wick Assembly	23023
1 'O'-Seal	041202
1 'O'-Seal coated	042806
2 Copper compression washers	042805
1 Temperature Sensitive Unit	22620
2 'O'-Seals	0501
2 BAL Seals	0675
1 Bobbin Assembly	23123
1 'O'-Seal	041105
1 PTFE 'O'-seal	0579
1 Top Seal	23046

For other parts please refer to the reference number on the figures and the detailed lists which follow.

Fig. 2 Closing Mechanism

MULTI PACK PART NO.	REF.	PART NO.	QTY		
	1	031010	1	Spring	
	2	23123	1	Bobbin Assembly	K5
201525	3		1	O-Ring	K5
	4	23094	1	Spool	
201503	5		1	O-Ring	K5
201524	6		1	BAL Seal	K5
	7	23098	1	Cover Plate	
	8	60152	1	Spring	
200211	9		1	Circlip	
	10	23022	1	Push Rod Assembly	
	11	23011	1	Bush Assembly	
200710	12		4	M3 Washer	
200212	13		2	M3 × 8 screw Ch. Head	
200213	14		2	M3 × 25 screw Cap Head	

Fig. 3 Temperature Compensator

MULTI PACK PART NO.	REF.	PART NO.	QTY		
	1	0501	2	O-Seal	
	3	23136	1	Temperature Compensator Cap	
	4	23187	1	Lock Nut	
	5	23134	1	Spring Adjuster	
200001	6		1	Spring	
200208	7		2	E-Clip	
	8	23183	1	Temperature Indicator Shaft	
	9	23130	1	Temperature Compensator Bobbin	
201521	10		1	O-Seal	K5
201522	12		2	Copper Compression washer	K5
	13	23137	1	Temperature Compensator Connector	
	14	23132	1	Temperature Sensitive Push Rod	
	15	22620	1	Temperature Sensitive Unit	K5
	16	23043	3	Stud	

Fig. 4 Concentration Control Valve

MULTI PACK PART NO.	REF.	PART NO.	QTY		
	1	23138	1	Blanking Plug 2 × 10.1	
201523	2		1	O-Seal	K5
	3	23066	1	Seat Retainer	
	4	23067	1	Valve Seat	
	5	23065	1	Seal Seat	
	6	23095	1	Screw	
200709	7		6	Spring Washers	
200710	8		2	M3 Washer	
200209	9		2	M3 x 4 screw Ch. Head	
201524	10		1	BAL Seal	K5
	11	23129	1	Idler Shaft Assembly	
	12	23188	1	Gear Locking Cam	
200208	13		1	E-Clip	
200710	14		2	M3 Washer	
200210	15		1	M3 × 8 screw Cap Head	
	16	015009	1	Idler pinion	
	17	23213	1	Halothane and Isoflurane Needle assembly	
		23214	1	Enflurane 5% Needle assembly	
		23215	1	Enflurane 7% Needle assembly	
200207	18		1	M3 × 12 screw Cap Head	

Fig. 5 Standard Filler

MULTI PACK PART NO.	REF.	PART NO.	QTY			
	1	22729	1	Knob Assembly		K1
	2	23061	1	Drain Screw		
	3	22466	1	Drain Valve Gasket		
	4	22428	1	Drain Valve		
	5	23062	1	Seal Carrier	) Parts common	
201521	6		3	O-Seal	) to Fig. 6 and	K1
	7	23063	1	Glass Level Tube	) Fig. 7	
	8	23064	1	Bobbin	)	

Fig. 6 Keyed Filler

MULTI PACK PART NO.	REF.	PART NO.	QTY		
	1	23077	1	Knob	
200214	2		2	Grub Screw	
200215	3			Screw	
	4	23074	1	Valve Cap	
	9	23081	1	Sealing Strip	
200216	10		4	Screw	
	11	23076	1	Clamp Screw	
	12	020404	1	Retainer	
	13		as reqd	Index Block (NOT available as spare)	
	14	22551	1	Slipper Block	
	15	23079	1	Valve assembly (Pin 23058)	
	16	23082	1	Valve	
201512	17		1	PTFE O-Seal	
201526	18		2	PTFE O-Seal	K5
	19	23246	1	Sleeve Seal Support	
	Not illustrated. Parts used to attach Filler Body to Chamber.				
	–	22567	1	Gasket	
200217	–		2	M4 × 10 Cap Head Screw	
200711	–		2	M4 Washer	

Fig. 7 Wick System

MULTI PACK PART NO.	REF.	PART NO.	QTY		
200204	1		4	2 BA Screw Cap Head 1¼ in	
	2	23161	1	Connector block Back Entry (not Enflurane)	
	2A	23223	1	Connector block Back Entry (Enflurane)	
	3	400587	1	Back Plate	
200205	4		4	M5 x 12 Screw Cap Head	
	5	23160	1	Connector block Cagemount (not Enflurane)	
	5A	23222	1	Connector block Cagemount (Enflurane)	
	6	23198	1	Spacer	
	7	22693	5	Shim	
	8	36052	1	Back Bar Clamp } Cagemount	
	9	23195	2	Stud } fitting only.	
200707	10		2	6 mm Washer	
200206	11		2	M6 Nut	
201519	12		2 (cm) 4 (BE)	O-Seal	K1
	13	23043	3	Stud	
	14	23044	1	Sealing Washer	K1
201520	15		1	O-Seal	K1
	16	23025	1	Tube Coil	
	17	23023	1	Wick Assembly	K5
	18	23042	1	Clamp Plate	
	19	23045	3	Clamp Screw	

NOTE Items included in Servicing Kits are marked K1 (annual) – K5 (5 year)

Fig. 8 Enflurane Connector Block

MULTI PACK PART NO.	REF.	PART NO.	QTY		
	1	23250	1	Cagemount block (Enflurane)	
	2	23252	1	Relief valve plunger	
	3	0691	1	'O' seal	
	4	031012	1	Spring	
	5	23254	1	Retaining disc	
	6	01068	1	M3 x 8 Screw	
	7	025201	1	M3 Washer	
	8	23195	2	Studs	

Fig. 9 Body Assembly

MULTI PACK PART NO.	REF.	PART NO.	QTY		
	1	23150		Cover Halothane (Rear Entry)	
		23164	1	Cover Halothane (Cagemount)	
		23151		Cover Enflurane (Rear Entry)	
		23165	1	Cover Enflurane (Cagemount)	
		23152		Cover Isoflurane (Rear Entry)	
		23166	1	Cover Isoflurane (Cagemount)	
200202	2		2	2BA Screw Cap Head 2 in	
200203	3		2	2BA Screw Cap Head 1¾ in	
200706	4		4	2BA Washer	
	6	23054	1	Spacer	
	7	042806	2	O-Seal Coated	K1
	8	01067	4	Washers M3	
	9	019002	4	Screw M3	

8. REFERENCES

The Keyed Filling System used with these vaporizers is manufacturerd by Penlon under licence from Ohmeda, a Division of BOC Health Care.

The PPV is the subject of patents in the United Kingdom and other countries.

Patent number 1 193 241 applies in the United Kingdom.

Standards

The following Standard documents refer to vaporizers:–

(a) General

ISO	–	Continuous flow inhalational anaesthetic apparatus (anaesthetic machines) for use with humans ISO 5358, 3, 1980: Section 12, 14, 15.
Canada	–	for use with humans CSA Z168.3. 1979: Section 12, 14 15
USA	–	for use with humans ANSI Z79.8. 1979: Section 12, 13
W. Germany	–	Inhalationsnarkosegeräte DIN 13252: Section 4.9–4.13 and 5.9–5.13

(b) Keyed Filling System

Canada. Keyed Filling Devices for Anaesthetic Vaporizers Z168.4 M82

W. Germany. Inhalationsnarkosegeräte DIN 13252: Section 4.11 and 5.11.

(c) Anaesthetic Gas Scavenging System

ISO	DP 7281
Canada	CSA Z168.8
USA	ANSI Z79.11
UK	BS 6834

9. APPENDIX 1

PPV SELECTATEC* COMPATIBLE VAPORIZER

Addendum to be used in conjunction with Service Manual 53424

1. PURPOSE

This document provides additional service details for the PPV Selectatec Compatible vaporizer. For all other service details, refer to the PPV Vaporizer Service Manual 53424.

2. WARNINGS

1 Servicing must only be undertaken by Penlon authorized service personnel.

2 Before being returned to service, leak tests must be performed.

3. SERVICE FREQUENCY

A full inspection must be carried out as part of the vaporizer 3 – 6 month function test, no additional preventative maintenance is required.

4. SERVICE INSPECTION

4.1 Ensure that the block is clean and free from contamination.
Clean with a soft dry cloth.

4.2 Inspect the sealing counterbores of the gas connection parts.
If they are damaged a replacement block will be required.

4.3 Inspect the condition of the claws on the locking shaft; if worn or damaged the locking shaft must be replaced.

4.4 Inspect the condition of the button plate; if either bent, or damaged, it must be replaced.

*Selectatec is a BOC Group trademark

5. REPAIR PROCEDURES (Fig. A)

Repairs must be carried out with the vaporizer removed from the anaesthetic machine:

5.1 Compatibility block replacement

5.1.1 Remove the four M3 (019002) screws attaching the vaporizer top cover and place the top cover and screws to one side.

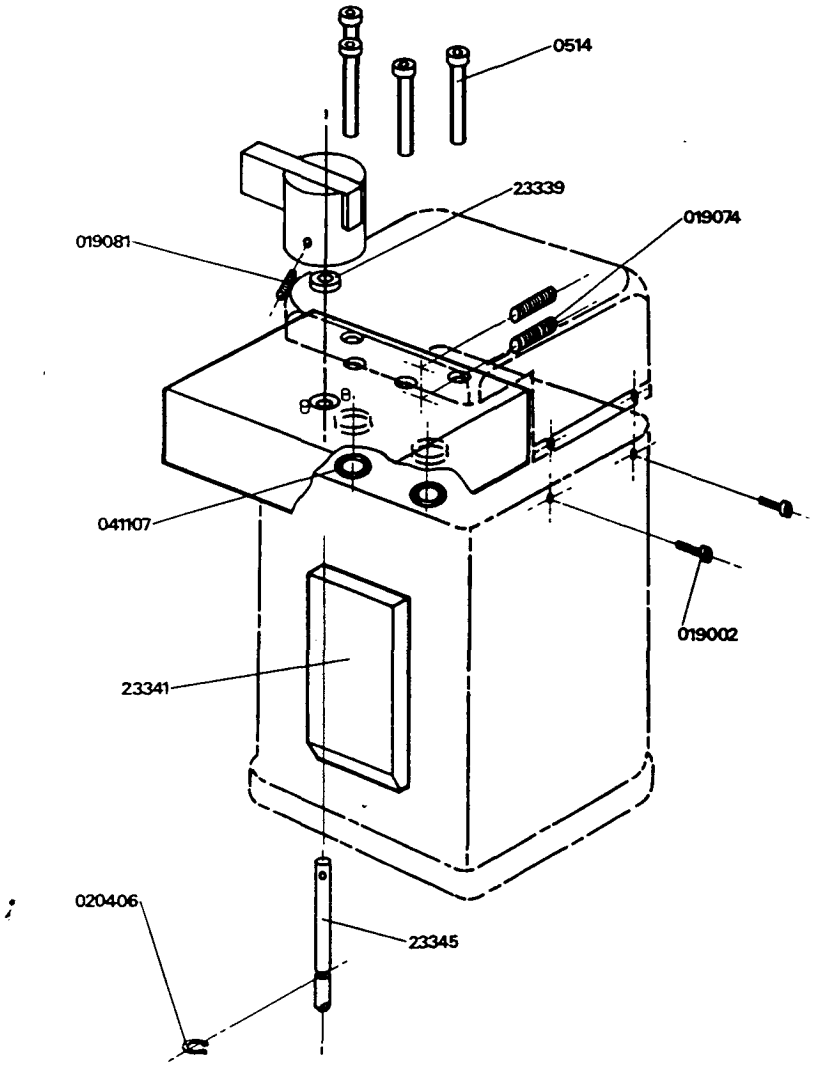
5.1.2 Remove the four 2BA × 1¼ in long screws (0514) securing the compatibility block to the vaporizer valve block and retain the screws.

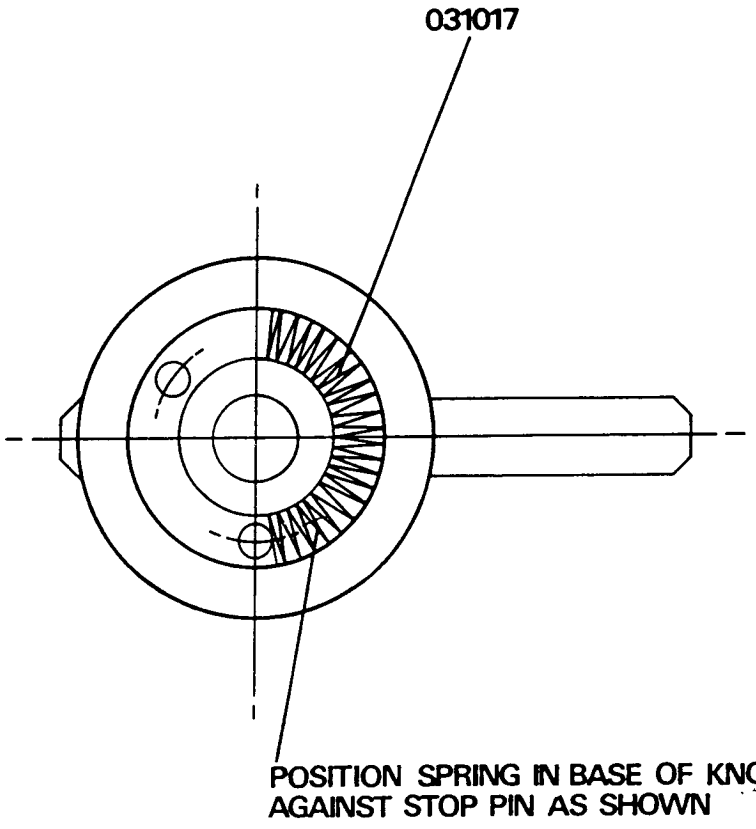
5.1.3 Fit two new 'O' seals (041107) to the replacement compatibility block.

5.1.4 Fit the new block assembly and replace the screws (0514).

5.1.5 Test the joints for gas tightness. See Section 6.

5.1.6 Replace lid.





5.2 **Locking shaft replacement**

5.2.1 Remove the M3 × 12 long grub screw (019081) from the locking knob and place to one side.

5.2.2 Remove the knob and washer, place to one side; withdraw the locking shaft with circlip and discard.

NOTE When removing the knob ensure that the return spring is not dislodged.

5.2.3 Install a new circlip (020406) onto the replacement locking shaft (23345), lightly coat the locking shaft with an oxygen compatible lubricant, i.e. Fomblin, and insert into the compatibility block. Replace the washer (23339) onto shaft.

5.2.4 Locate the return spring (031017) in the knob base in the position shown on Fig. B and fit the knob onto the locking shaft ensuring that:

1. The register on the locking shaft aligns with the grubscrew (019081) hole in the knob.

2. The travel limiting pins on the block are correctly fitted into the recess on the base of the locking knob. See Fig. 1.

Insert the locking screw (019081) and tighten.

5.2.5 Perform a function test before returning the unit to service. (See Section 6).

5.3 Button plate replacement

5.3.1 Remove the four M3 screws attaching the vaporizer top cover and place the top cover and screws to one side.

5.3.2 Slacken the two M5 × 16 long grub screws (019074) and withdraw the button plate (23341).

5.3.3 Insert the new button plate (23341) ensuring that the lead chamfer is facing towards the locking shaft.

5.3.4 Ensuring that the button plate is fully inserted to the bottom of the slot, tighten the two grub screws.

5.3.5 Replace the compatibility block as detailed in 5.1.

5.3.6 Test the security of the fixings and perform a function test, see section 6.

6 FUNCTION TEST

6.1 Before replacing the correct colour coded lid check that all compatibility block securing screws are tight.

6.2 Fit the vaporizer onto a Selectatec type back bar and lock vaporizer onto the system. Ensure that the locking lever is fully engaged in the locked position.

6.3 Perform leak tests as detailed in the relevant anaesthetic machine service manuals. Maximum permissible leak rate less than 10 ml/min at 60 mm Hg.

Part No		Description	Qty.
23345	–	Locking shaft) to be replaced	1
020406	–	Circlip) together	1
23339	–	Washer	1
031017	–	Spring	1
019081	–	M3 × 12 grub screw	1
019074	–	M5 × 16 grub screw	2
23341	–	Button plate	1
23314	–	Compatibility block assembly complete	1
041107	–	'O' Seals	2

NOTES

NOTES

USER RESPONSIBILITY

This anaesthetic device has been built to conform with the specification and operating procedures stated in this manual and/or accompanying labels and notices when checked, assembled, operated, maintained and serviced in accordance with the instructions provided. To ensure the safety of this device, it must be checked and serviced to at least the minimum standards laid out in this manual. A defective, or suspected, defective product must not under any circumstances be used.

Worn, broken, distorted, contaminated or missing components must be replaced immediately. Should such a repair become necessary, it is recommended that a request for service advice be made to the nearest Penlon Service Centre.

This device and any of its constituent parts must be repaired only in accordance with written instructions issued by Penlon Ltd. and must not be altered or modified in any way without the written approval of Penlon Ltd. The user of this equipment shall have the sole responsibility for any malfunction which results from improper use, maintenance, repair, damage or alteration by anyone other than Penlon Ltd. or its appointed agents.

USA and Canadian Federal Law restricts the sale and use of this device to, or on the order of, a licensed practitioner.

SERVICE POLICY

The PPV is serviced according to the following system:

a) At regular intervals (3 months minimum: 6 months maximum) the calibration is checked under controlled conditions and leak tests are performed. The measured figures are recorded in this book. These tests ensure that the vaporizer is in good condition at the time of the test, or it is withdrawn from service. See section 6.3.

b) By comparing several sets of successive figures, a trend in performance can be established and withdrawal from service may be forecast, before the performance has actually deteriorated severely. A major service would then be applied to restore normal operation. See section 6.4.

c) All vaporizers must be fully overhauled and certain items replaced every 5 years, even if performance appears satisfactory. This is a preventive maintenance requirement. See section 6.5.

This book therefore includes 5 pages each with 4 spaces for 3-monthly figures to be recorded. When the book is full, the PPV must be fully overhauled and a new service book will be issued for the next 5 years.

The procedure of Service Test is detailed in section 6.3.

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Service Record Book
for
PPV VAPORIZER

Cat. No.	**Agent**
Serial No.	
Date of Installation	
Departmental No.	
Serviced by	
Contact telephone	

THIS BOOK SHOULD BE KEPT IN THE DEPARTMENT OF ANAESTHESIA RECORDS AND UPDATED AT EACH SERVICE BY THE SERVICE ENGINEER.

Notes on Calibration procedure using the Riken Model 18 Inteferometer

The Riken Model 18 is normally supplied calibrated for Halothane 0-6% vol, either in air or in oxygen.

Service checks on the PPV will be performed with oxygen if the vaporizer is checked on an anaesthetic machine, and may be performed with air or with oxygen in a test laboratory.

CAUTION It is essential that the gas used is recorded and that the reference cell of the Riken is purged with the appropriate gas before measurements are made.

AGENTS

The Riken gas analyser measures the refractive index of the gases and vapours and, although normally calibrated for measuring halothane, the instrument can also measure any other vapour if an appropriate factor is applied.

The factors below are applied by multiplying the reading of the Riken to obtain the true concentration.

CARRIER GAS

The refractive index of oxygen is higher than that of air so that (a) the unit must be re-zeroed if the carrier gas is changed; (b) the scale must be adjusted by a factor, applied by multiplying the Riken scale reading to obtain true concentration.

Halothane in Air Riken

Using Air	Factor	Using Oxygen	Factor
Halothane	1		1.06
Enflurane	1.05		1.11
Isoflurane	1.06		1.12

Halothane in Oxygen Riken

Using Air	Factor	Using Oxygen	Factor
Halothane	0.95		1
Enflurane	0.99		1.05
Isoflurane	1.00		1.06

The readings of the Riken are also affected by temperature and barometric pressure.

PPV calibration checks must be performed at a temperature between 20 and 22°C. The correction factor is therefore ± 1½% of readings which is negligible in view of the accuracy of the instrument. Temperature correction is therefore not required, but the temperature should be measured and recorded to ensure that the test is carried out within the specified range.

Changes of barometric pressure due to weather are not normally of significance and can be ignored.

Altitude can, however, have significant effects and the following factors should be applied when appropriate. Again, Riken reading x factor = true concentration corrected to STP.

Altitude	**Correction factor**	**Barometric pressure** (for reference)
2000 ft.	x 0.9	910 mb
4000 ft.	x 0.85	850 mb
6000 ft.	x 0.8	813 mb

Method of reading the Riken analyser

1. Readings may be taken from a tee-piece connected to the common gas outlet of the anaesthetic machine. An AGS system must be connected.

2. The sampling tube should be nylon or PTFE (which do not absorb vapours). Rubber sleeves may be used to make end connections but there must be minimal length of rubber exposed to the gases being sampled.

3. Sample by 2 or 3 squeezes of the hand bulb. Wait for fringe movement to cease before taking the reading.

4. After each setting of the vaporizer control, time must be allowed for the output to stabilize.

   Suggested time scale @ 2 l/min flow – wait 4 minutes
   4 l/min flow – wait 2 minutes
   8 l/min flow – wait 1 minute.

5. As stated in the Service Manual:

   a) The vaporizer must be half to three quarters full, and rigidly supported in its operating position.

   b) Temperatures must be stabilized for approx. ½ hour before checking.

   c) Temperature must be in the range 20° – 22°C.

Serial No.					
Agent					
Test Period		1	2	3	4
Date					
Signature					
Carrier Gas					
Overall leak rate: less than 200 ml/min flow for 150 mm Hg.					
Set	Tolerance				
0.0	0–0.1				
0.4	0.2–0.6				
1.0	0.8–1.2				
2.0	1.6–2.4				
3.0	2.4–3.6				
4.0	3.2–4.8				
5.0	4.0–6.0				
7.0	5.6–8.4				
5.0	4.0–6.0				
4.0	3.2–4.8				
3.0	2.4–3.6				
2.0	1.6–2.4				
1.0	0.8–1.2				
0.4	0.2–0.6				
0.0	0–0.1				
Set carrier gas 4 l/min					8 l/min

Comments:

Serial No.					
Agent					
Test Period		1	2	3	4
Date					
Signature					
Carrier Gas					
Overall leak rate: less than 200 ml/min flow for 150 mm Hg.					
Set	Tolerance				
0.0	0–0.1				
0.4	0.2–0.6				
1.0	0.8–1.2				
2.0	1.6–2.4				
3.0	2.4–3.6				
4.0	3.2–4.8				
5.0	4.0–6.0				
7.0	5.6–8.4				
5.0	4.0–6.0				
4.0	3.2–4.8				
3.0	2.4–3.6				
2.0	1.6–2.4				
1.0	0.8–1.2				
0.4	0.2–0.6				
0.0	0–0.1				
Set carrier gas 4 l/min					8 l/min

Comments:

Serial No.					
Agent					
Test Period		1	2	3	4
Date					
Signature					
Carrier Gas					
Overall leak rate: less than 200 ml/min flow for 150 mm Hg.					
Set	Tolerance				
0.0	0–0.1				
0.4	0.2–0.6				
1.0	0.8–1.2				
2.0	1.6–2.4				
3.0	2.4–3.6				
4.0	3.2–4.8				
5.0	4.0–6.0				
7.0	5.6–8.4				
5.0	4.0–6.0				
4.0	3.2–4.8				
3.0	2.4–3.6				
2.0	1.6–2.4				
1.0	0.8–1.2				
0.4	0.2–0.6				
0.0	0–0.1				
Set carrier gas 4 l/min					8 l/min

Comments:

Serial No.					
Agent					
Test Period		1	2	3	4
Date					
Signature					
Carrier Gas					
Overall leak rate: less tnan 200 ml/min flow for 150 mm Hg.					
Set	Tolerance				
0.0	0–0.1				
0.4	0.2–0.6				
1.0	0.8–1.2				
2.0	1.6–2.4				
3.0	2.4–3.6				
4.0	3.2–4.8				
5.0	4.0–6.0				
7.0	5.6–8.4				
5.0	4.0–6.0				
4.0	3.2–4.8				
3.0	2.4–3.6				
2.0	1.6–2.4				
1.0	0.8–1.2				
0.4	0.2–0.6				
0.0	0–0.1				
Set carrier gas 4 l/min					8 l/min

Comments:

Serial No.					
Agent					
Test Period		1	2	3	4
Date					
Signature					
Carrier Gas					
Overall leak rate: less than 200 ml/min flow for 150 mm Hg.					
Set	Tolerance				
0.0	0–0.1				
0.4	0.2–0.6				
1.0	0.8–1.2				
2.0	1.6–2.4				
3.0	2.4–3.6				
4.0	3.2–4.8				
5.0	4.0–6.0				
7.0	5.6–8.4				
5.0	4.0–6.0				
4.0	3.2–4.8				
3.0	2.4–3.6				
2.0	1.6–2.4				
1.0	0.8–1.2				
0.4	0.2–0.6				
0.0	0–0.1				
Set carrier gas 4 l/min					8 l/min

Comments: